

The American Midland Naturalist

Founded by J. A. Nieuwland, C.S.C.

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John D. Mizelle, *Editor*

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JULY, 1951

No. 1

Seeds of the Cruciferae of Northeastern North America*

Margaret R. Murley

Northwestern University, Evanston, Illinois

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Introduction

PURPOSE OF STUDY

Seeds have been neglected taxonomically, while leaf, flower and fruit characters have occupied a prominent place with the systematist. In the last thirty years, however, studies concerning seed characters primarily for the purpose of identifying isolated seeds have been on the increase. The determination of isolated seeds is necessary for seed testing laboratories, the United States Department of Agriculture, Foreign Plant Industry, Federal Bureau of Investigation, and in such fields as wildlife conservation, archaeology and paleobotany. As a result a few seed and fruit keys have been prepared either to selected species of several families (Palmer, 1916), or to certain genera (Conley, 1938; Francois, 1937; Musil, 1944a, 1944b, 1944c, 1945, 1948), or selected species of a particular family (Winston, 1916), or to families or genera as represented in political areas or regions (Bertsch, 1941; Bomhard, 1926; Cernohorsky, 1947; Murley, 1944, 1945, 1946), and to a synoptic treatment by families (Beijerinck, 1947; Isely, 1947).

The present study has been approached with several objects in view, namely: (1) the preparation of two seed keys to the Cruciferae on a regional basis for practical purposes, accompanied by full taxonomic descriptions of each species to supplement the key; (2) a seed glossary with adequate terminology for the Cruciferae, the terms chosen and standardized so as to be suitable for the description of seeds of other families; (3) mass collection studies

* A dissertation submitted to the Graduate School of Northwestern University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

on selected species to validate the characters used in the keys and descriptions; (4) descriptive research that may contribute to a more satisfactory natural classification of the family, involving further detailed factual information on the seed, more especially the seed coat, wing and the hilar region.

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Plant collections have been obtained from several herbaria and certain herbaria have been visited:

United States National Herbarium—courtesy of Mr. E. P. Killip
Chicago Natural History Museum Herbarium—courtesy of Dr. Theodor Just
University of Illinois Herbarium—courtesy of Dr. G. N. Jones
Illinois State Museum Herbarium—courtesy of Dr. G. D. Fuller
Herbarium of Iowa State College—courtesy of Dr. Ada Hayden
Herbarium of Ralph Kriebel, Purdue University—courtesy of Dr. G. B. Cummins
Butler University Herbarium—courtesy of Dr. Ray C. Friesner
Deam Herbarium—courtesy of Mr. C. C. Deam

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Miss Miriam Bomhard gave considerable help in suggesting references that are found in the bibliography.

Dr. Reed Rollins, Director of the Gray Herbarium, Harvard University, has kindly checked all the names and brought them in agreement with the new edition of *Gray's Manual*.

Most of the illustrations were drawn by Miss Marie Wilson. *Brassica* illustrations were made by Regina Olson Hughes and are here reproduced with the permission of Miss Albina Musil.

Dr. Roland W. Brown, of the U. S. Geological Survey, U. S. National Museum, checked the section on terminology.

The manuscript was read and the seed keys tested by Professor Duane Isely of Iowa State College. Mr. Dale West assisted in the seed key testing.

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Materials and Methods

Collections of seeds from properly identified plants were made over a period of three years. The seeds were studied with the use of a binocular microscope largely at magnifications of 45, and frequently certain details of structure were confirmed at 60 magnification. Descriptions of each species were kept on separate four by six inch cards. This device aided in the preparation of the keys.

In attempting to arrive at a generalized or typical seed of each species, at least 20 seeds from each sample were studied (if that many were available), and, whenever possible, collections were selected from several different areas of the United States. In the case of a species in which both mass collections from 25 plants and samples from several areas in the United States were obtained the total number of seeds examined for the species was over 800. A total of 30,000 seeds was examined in the course of the study.

The sources of seeds fall into three main categories:

- A. Herbaria—cited by the following abbreviations in the taxonomic descriptions:
 BUT—Butler University, Indianapolis, Ind.
 F—Chicago Natural History Museum, Chicago, Ill.
 ILL—University of Illinois, Urbana, Ill.
 IND—Indiana University, Bloomington, Ind.
 ISC—Iowa State College, Ames, Ia.
 ISM—Illinois State Museum, Springfield, Ill.
 Kb—Ralph Kriebel Herbarium, Agricultural Experiment Station, Purdue University, Lafayette, Ind.
 US—United States National Herbarium, Washington, D. C.
- B. Seed Collections—cited by the following abbreviations:
 CSL—California State Seed Laboratory, Sacramento, Calif.
 FPI—Foreign Plant Industry, Wash., D. C. (includes range speices of the U. S.)
 FSL—Federal Seed Laboratory, Washington, D. C.
 ISCSL—Iowa State College Seed Laboratory, Ames, Ia.
 MSL—Minnesota State Seed Laboratory, Minneapolis, Minn.
 P—Patuxent Wildlife Refuge, USDA.
 PSL—Purdue Seed Laboratory, Lafayette, Ind.
- C. Mass Collections by the writer.

These collections of twenty-two species were made largely in the Chicago area during the summers of 1947 and 1948. A colony was located, tagged, and both plant and seeds collected at maturity. For certain species seeds from the extreme base and the extreme apex of the raceme were collected separately, usually several days to a week apart. Collections and data are as follows:

<i>Alliaria officinalis</i>	colony of 25	July 4, 15, 1948	Winnetka, Ill.
<i>Arabis dentata</i>	colony of 10	July 4, 1948	Wheeling, Ill.
<i>Arabis laevigata</i>	20 plants; separate collections from both base and apex of raceme	July 25, 1948	Harm's Woods, Evanston, Ill.
<i>Arabis laevigata</i>	36 plants; separate collections from both base and apex of raceme	Aug. 23, 1948	Harm's Woods, Evanston, Ill.
<i>Arabis lyrata</i>	5 plants	July 18, 1948	Tremont, Ind. Dunes
<i>Barbarea vulgaris</i>	colony of 15 plants; separate collections from base and apex	July 25, 1948	Harm's Woods, Evanston, Ill.

<i>Berteroa incana</i>	colony of 20 plants	July 18, 1948	Van Buren Co., Mich. Jane Roller
<i>Berteroa incana</i>	8 plants	July 31, 1948	Dickinson Co., Iowa Ada Hayden
<i>Berteroa incana</i>	9 plants	Aug. 3, 1948	Palo Alto Co., Iowa Ada Hayden
<i>Brassica kaber</i>	colony of 20 plants	July 31, 1948	Growing on rock pile Wilmette Cinerator
<i>Brassica nigra</i>	colony of 7 plants	Aug. 5, 1948	Waukegan State Park, Ill.
<i>Cakile edentula</i>	colony of 13 plants	Oct. 9, 1948	Warren Sand Dunes, Berrien Co., Mich.
<i>Cakile edentula</i>	12 plants	Oct. 1, 1947	Waukegan State Park, Ill.
<i>Capsella bursa-pastoris</i>	colony of 25	July 4, 1948	Wilmette, Ill.
<i>Capsella bursa-pastoris</i>	12 plants	July 21, 1948	Lawn in Evanston, Ill.
<i>Cardamine bulbosa</i>	two colonies of 20; seeds collected from base and apex	June 7, 10, 1948	Harm's Woods, Evanston, Ill.
<i>Cardamine Douglassii</i>	colony of 20 plants; seeds collected from base and apex	June 7, 10, 1948	Harm's Woods, Evanston, Ill.
<i>Cardamine pennsylvanica</i>	two colonies of 20 plants; seeds collected from base and apex	June 10, 1948	Harm's Woods, Evanston, Ill.
<i>Dentaria laciniata</i>	three colonies of 25 plants each	June 9, 1948	Thatcher's Woods, Chicago
<i>Diplotaxis muralis</i>	colony of 25 plants	Aug. 5, 1948	Waukegan State Park, Ill.
<i>Diplotaxis muralis</i>	same colony of 25 plants	Sept. 4, 1948	Waukegan State Park, Ill.
<i>Erysimum cheiranthoides</i>	colony of 25 (normal plants); seeds collected from base and apex	July 11, 15, 1948	Skokie Lagoon Glencoe, Ill.
<i>Erysimum cheiranthoides</i>	colony of 25 (de- pauperate plants); seeds collected from base and apex	July 11, 16, 1948	Skokie Lagoon Glencoe, Ill.
<i>Erysimum cheiranthoides</i>	colony of 25 plants second growth	Aug. 5, 1948	Waukegan State Park, Ill.
<i>Lepidium campestre</i>	colony of 25 plants	July 11, 1948	Skokie Lagoon

<i>Lepidium virginicum</i>	colony of 25 plants; July 28, 1948 seeds from base of raceme	Foster St., Garden Lot, Evanston, Ill.
<i>Lepidium virginicum</i>	same 25 plants; seeds Aug. 6, 1948 from apex of raceme	Foster St., Garden Lot, Evanston, Ill.
<i>Lepidium virginicum</i>	colony of 20 plants July 31, 1948	Growing on rock pile of Wilmette Cinerator
<i>Rorippa islandica</i>	9 plants July 25, 1948	Harm's Woods, Evanston, Ill.
<i>Rorippa islandica</i>	5 plants July 31, 1948	Harm's Woods, Evanston, Ill.
<i>Rorippa islandica</i>	12 plants Aug. 13, 1948	Harm's Woods, Evanston, Ill.
<i>Rorippa islandica</i>	10 plants Aug. 7, 1948	Pond near Wilmette Cinerator
<i>Sisymbrium altis- simum</i>	colony of 25 plants; Sept. 9, 1948 separate collections from base and apex	Spur Railroad, Emerson St., Evanston, Ill.
<i>Sisymbrium altis- simum</i>	20 plants Sept. 13, 1947	Spur Railroad, Emerson St., Evanston, Ill.
<i>Sisymbrium officinale</i>	colony of 25 plants; Sept. 6, 1948 separate collections from base and apex	Garden Lot, Sherman Ave., Evanston, Ill.
<i>Sisymbrium officinale</i>	20 plants Sept. 4, 1947	Lake Michigan shore, Northwestern cam- pus, Evanston, Ill.
<i>Thlaspi arvense</i>	colony of 25 plants July 4, 1948	Skokie Lagoon, Glencoe, Ill.

Seed Morphology and Classification of the Cruciferae

SEED MORPHOLOGY

The seeds described in this dissertation represent species of the Cruciferae found in Northeastern North America, approximately in the range treated in *Gray's Manual* (Fernald, 1950). Seeds of a few species have been omitted because mature seeds were not available: *Armoracia lapathifolia* and *Dentaria* sp. As the range of a number of the species extends into Canada as well as westward, the plan is to include all species of this natural region when more material and further data on distribution are available. A few species have been included whose known distribution is Canada: *Arabis alpina*, *A. arenicola*, *Braya Longii*, *Cochlearia officinalis*, *Draba fladnizensis*, *D. glabella*, *Halimolobos mollis*. In addition a few cultivated species, reported as sporadically naturalized have also been included: *Cheiranthus Cheiri*, *Iberis amara*, *Matthiola incana*, *Myagrum perfoliatum*. Since the possible bearing of seed structure on natural classification is being considered, representative species of several

additional genera are appropriately included. The large number of naturalized species and varieties, 62 out of the 123 entities studied, is due partly to their prolific seeding and partly to the ease with which they become established under different environmental conditions.

The seed is highly characteristic for this family, as are other plant structures, particularly the flower and fruit. To place an unknown seed in this family is usually not difficult. The following combination of some or all of the characters are reliable:

EXTERNAL

1. A prominent longitudinal radicular ridge set off from the cotyledonary portion of the seed.

2. A primary longitudinal groove marking the division between the radicular ridge and the cotyledons dividing the seed roughly into one-third and two-third sections. The primary groove closely parallels the radicular ridge and the radicular edge of the seed.

3. A secondary longitudinal groove frequently present dividing the seed roughly into three one-third sections. When evident the presence of the secondary groove is a mark of incumbent cotyledons. However, incumbent cotyledons do not always display the secondary groove.

4. A notch, or, if considerably expanded, a cleft at the base of the seed, parting the radicle and cotyledons.

5. Claws—cotyledonary and radical bases may take on the form of appendages when the cleft is prominent.

6. Funicular tissue abundant and proliferating, frequently in the form of a triangle termed the "crest" and filling the cleft.

7. Funiculus proper persistent, seed frequently detached from the fruit not strictly at the hilum but the funiculus breaking midway leaving a peg-like piece attached to the seed.

8. Presence of cuticle which, if it does not slough off in seed coat maturation, gives a glistening appearance to the seed coat.

9. A mucilaginous substance, peculiar to the family, which in diffusing out of the epidermal cells or merely swelling has diagnostic significance. When the seeds of certain species are placed in water, a mucilaginous envelope or halo forms around them.

10. A seed coat usually highly organized; reticulate, pitted, tuberculate, verrucate. This is related in part to the mucilage which either breaks or diffuses through the outer cell walls and cuticle and is deposited in a manner characteristic of the species, and in part to the shape and form of the epidermal or the palisade cell layers of the seed coat.

11. Wing frequently present and of some generic importance.

12. Edge of seed may have a conspicuous margin—said to be "emarginate."

13. Hilum region sometimes conspicuous being elongated and banded; at other times inconspicuous.

14. Shape of seed falls into two broad categories (a) compressed or flattened and (b) globose. In this family the compressed seed is by far the more numerous. The external characters listed above are true for the compressed seed, but many are not characteristic for the globose seed.

INTERNAL

1. A campylotropous seed. Martin (1946) refers to the embryo in such seeds as "bent."

2. Cotyledons arranged in five different positions depending on how the embryo is bent or twisted—namely: accumbent, incumbent, obliquely incumbent, transversely folded incumbent and conduplicate. The accumbent and incumbent cotyledons rarely occur in other families. (Resedaceae, incumbent cotyledons.)

3. Endosperm reduced to one or two rows of cells, the embryo occupying most of the interior of the seed.

4. Embryo oily.

5. Several cuticular layers present, at least in the early stages of seed coat differentiation (Netolitsky, 1926).

That the internal anatomy may find expression externally is evidenced by marks of the cotyledons and the radicular ridges on the outer surface that aid in a ready recognition of the seed to the family, and by frequently being able to determine the type of cotyledon without making a cross-section as in *Arabis* species. In *Subularia aquatica*, the transversely folded incumbent cotyledons are strikingly delimited exteriorly. In addition the development of mucilage is of some value both for specific and sectional or subtribal characters (Janchen, 1942).

Since considerable time has been spent on the external morphological details of the seed coat and such details are used in the keys as diagnostic characters, discussion of a few anatomical facts may be appropriate in this connection. Though characters easily recognizable at magnifications of 45 to 60 are used in the key to facilitate a rapid identification, they will be more readily understood if some information is given about the nature of these configurations on the seed coat.

Normally the seed coat of the Cruciferae is made up of four layers: (1) epidermal, (2) parenchyma, (3) palisade, and (4) pigmented (Hayward, 1938). According to Winston (1916) the first and second seed coat layers of many species disintegrate, at least in part, at maturity. Thus, the palisade cells, highly distinctive in themselves, are important generic or specific characteristics and may be detected by an external examination (Netolitsky, 1926).

The mucilage develops at the expense of the starch, the latter being present in the epidermal cells in the early stages of seed coat development. The mucilage is formed in layers on the walls of the epidermal cells sometimes filling up the cells. (Mucilage is not present in all species.) Having the property of swelling, such seeds when placed in water, either swell up, or the outer cuticle and wall is broken and the mucilage being partly soluble in water comes out on the surface, piling up in a characteristic manner depending upon the species. In the latter case, the mucilage takes the place of the broken down epidermal cell. (Netolitsky, 1926). From the point of view of seed taxonomy mucilage is a valuable character as follows: (1) Its presence or absence (absent in *Alliaria*); if present: (2) lifting up the external membrane (outer wall cell and cuticle) without breaking it (Cernohorsky, 1947), (3) exuding gradually through a broken cuticle in the course of seed coat differentiation and piling up in a characteristic fashion, (4) coming out on the surface only when the seed is placed in water and developing a mucilaginous envelope, (5) swelling in all degrees or even lacking, (6) swelling at different stages of differentiation (in *Erysimum* according to Abraham (1885) the swelling takes place only on the unripe seeds), (7) varying in the length of time taken to develop a mucilaginous envelope when placed in water, (in the case of *Lepidium ruderalis* considerable time elapses; in the case of *Diplotaxis muralis*, the envelope forms immediately.) (Abra-

ham, 1885). As noted earlier, such differences in the activity of mucilage are found in species of the same genus.

If the epidermal cells stay intact and do not contract, a certain taxonomic value can be attributed to them. As an example, some species have alternately arranged high rounded epidermal cells and lower flat epidermal cells—namely, *Lepidium campestre*, giving a tuberculate seed coat (Cernohorsky, 1947).

A possible explanation for the differences in seed coat configuration on seeds of the same species or on various parts of one seed may be sought in the above listed facts of the seed coat. The stage of mucilage activity and the time of epidermal disintegration varies and frequently takes place after maturation of the seed proper. In the key such conditions are explained thus, "seed coat ocellate, alveolate in part." (See chapter on Mass Collections regarding observations on ecological factors of *Diplotaxis muralis*.)

CLASSIFICATION OF THE CRUCIFERAE

The classification of the Cruciferae has always been in a state of flux. Being a well-defined uniform family of approximately 350 genera and 3,000 species, it naturally follows that the Cruciferae are a difficult and technical group when attempting to classify the species within the family.

The general uniformity in the external characters of leaf, flower and inflorescence together with such internal structures as the myrosin cells and the folded cotyledons, and further the peculiar physiological aspects of sinigrin, myrosin and mucilage production separate this family clearly from all other plant families.

Therefore the systematists have been forced to use highly specialized characters in the subdivision of the family. Diagnostic characters have been sought in the following structures:

1. The stamens (Hayek, 1911) are at present considered of no value.
2. Flower color (Hayek, 1911) is no longer given much importance.
3. Honey glands (Crantz, *vide* Hayek, 1911). The type and position of the glands may be constant in some genera, but in many others are quite inconstant.
4. Habit has been given some value by Wettstein (1935).
5. Myrosin cells discovered by Heinricher in 1884 have been regarded by Schweidler (*vide* Hayek, 1911) as having high systematic value. These enzyme-containing idioblasts are present in all genera of the Cruciferae and occur in few other families (Capparidaceae, Resedaceae, Tropaeolaceae). It is, therefore, not only a family character but has some systematic value for sub-tribes or sections. Hayek (1911) has conveniently divided the myrosin cells into three kinds according to their position in the plant, namely: (a) mesophyll cells, (b) sieve tubes of the vascular bundles, and (c) mixed type, occurring in both places.
6. Trichomes are used in defining the tribes on the basis of being simple, forked, or stellate (Prantl, 1891). This classification has been severely crit-

ized by Hayek (1911) who feels that it separates genera closely related in many other characters such as *Descurainia* and *Sisymbrium*.

7. Stigma. The shape of the stigma according to Janchen (1942) has phylogenetic importance in separating primitive and advanced groups. Saunders (1923, 1925) used the position of the stigma in her studies on carpel polymorphism.

8. The fruit always occupied a prominent place with the early taxonomists and still does today with the systematists. Among the fruit characters considered are:

(a) Dehiscence. Bentham & Hooker (*vide* LeMaout et de Caisne, 1873) used it as a tribal character. Zohary (1948) regards the loss of dehiscence as an advanced character in carpel evolution. On the other hand, Hayek (1911) attributes little systematic value to dehiscence.

(b) Septum. (1) The histological structure of the epidermal cells helps in separating smaller genera, according to Janchen (1942). Payson concurs with this opinion in his studies of *Thelypodium* and closely related genera (1922) in which the cellular pattern is useful in delimiting genera. (2) Han-nig (1901) has classified the septa into complete, incomplete, apparently septumless, split, and entirely lacking. He, as well as Saunders (1923) believe that instability in this family is best expressed in the fruits.

(c) Vascular bundles. Their course in the fruit valve has, despite various morphological interpretations, in some cases specific value as in the genus *Lepidium* (Hitchcock, 1936; Thellung, 1913-1918).

(d) Shape. Linnaeus first used the differences in length of fruit to divide his class Tetradynamia into two major groups, namely, Siliquosae and Siliculosae. This was enlarged upon by De Candolle, then followed by Bentham and Hooker who established the following proportions of the fruits of the five major groups: (1) silique, (2) silicle, laptiseptal, (3) silicle, angustiseptal, (4) nucamentoid and (5) lomentoid. This classification has now fallen into disrepute. According to Schulz (1936) the length of the fruit is of little importance. Zohary (1948) in his carpological studies has proposed a new classification of seven divisions in which more fundamental differences are taken care of as well as degrees of dehiscence such as 'folliculoid'.

(e) Carpel evolution. Zohary (1948) considers the characters of the carpel in its evolution together with certain processes accompanying it such as seed number, loss of dehiscence and reduction of stylar parts; and he further re-evaluates the theory of the bicarpellary gynoecium. Saunders (1923), inspired by freak flowers of *Matthiola incana*, developed her well known theories of carpel polymorphism and of the tetracarpellary gynoecium. Acceptance of these theories would have a far-reaching bearing on the classification of Cruciferae.

Hayek (1911), in summary, considers the following fruit characters of systematic value if used in conjunction with other characters: (1) number of seeds in each fruit, (2) proportion and length and width of compartment, (3) nerves of the fruit, (4) number of compartments, (5) opening mechanism.

9. Seed. The internal anatomy of the seed has been used in the classification systems of the family since De Candolle (*vide* Le Maout et de Caisne, 1863) first used the cotyledonary positions, and is at the present given some systematic value as found in Hayek's (1911), Schulz's (1919, 1927, 1936) and Janchen's (1942) phylogenetic systems of classification. Other seed characters have been considered from the point of view of the identification of seeds apart from the plant. Anatomical structures of seed coat such as arrangement and development of tissues, the cell shape, origin and mode of mucilaginous exudation have been used by Abraham (1885), Harz (1885), Winston (1916), Netolitsky (1926) and Cernohorsky (1947) in identifying genera and species. Aside from the position of the cotyledons the seed is barely mentioned in classification problems. Payson in his studies of *Lesquerella* (1921) gives little value to seeds as diagnostic structures yet speculates on the primitive and the advanced seed. On the other hand, Rollins (1941) states that the seed is significant for the identification of *Arabis* species; and in his artificial key, the seed occupies a prominent place along with leaf, silique and pedicel characters.

Hayek (1911) was the first to present a phylogenetic system in which several characters are used: honey glands, myrosin cells, position of the cotyledons, shape of the stigma, fruit (previously discussed). To date this system represents one of the most complete phylogenetical accounts accompanied by descriptions of the genera. The seed characters used by him are, primarily, the type of cotyledon, occasionally shape such as flat or spheroid and presence of a wing or a conspicuous margin. He makes use of the type of cotyledon in merging the two genera, *Dentaria* and *Cardamine*. On the contrary Detling (1936) retains them as separate genera using rhizome and leaf characters. (See chapter on Taxonomic Descriptions, p. 35.)

Schulz (1936) departed somewhat from Hayek's system in placing greater emphasis on the flower as well as the honey glands. He, too, regards the position of the cotyledons as important in determining the phylogenetic arrangement of the tribes. Other seed characters such as presence of wings, shape, seed coat, development of a mucilaginous envelope, and the funiculus are used within the tribes and sub-tribes mainly for diagnosing the genera. The descriptions of the genera are detailed and the seeds are more fully described than in Hayek's work.

In order to maintain and strengthen Hayek's classification, Janchen (1942) who is in essential agreement with it, changed the position of a few genera and reversed the order of Lepidieae and Brassiceae. On the other hand, Janchen seriously objects to most of Schulz's innovations which would have essentially altered Hayek's system. Schulz too often disregards the factual relations where it is a question of preserving an artificial linear classification.

Sooner or later the taxonomy of many families requires the introduction and use of finer points in differentiating genera and species. Consequently in the Cruciferae, a large and highly uniform family, new and detailed information on their seeds is needed and likely to be of great value in solving crucial problems of classification.

Taxonomic Treatment

TERMINOLOGY

The following terms are defined as used in these keys and descriptions. Sources of definitions include Bischoff (1857), Germain (1870), Gray (1872), Jackson (1900), Voss (1929), Rydberg (1932), Snell (1936), Webster (1939), Jaeger (1944). In some cases, the definition is a composite from several sources. Latin equivalents are given in italics (a few are Greek, Anglo-Saxon, Middle Dutch, Middle English, French, Old French, or Old Norse, in origin). To circumvent the difficulties of semantics, an example with figure follows many of the definitions.

Accumbent, *accumbens*—referring to cotyledons when they lie with their edges against the radicular ridge. Used almost exclusively in the Cruciferae. *Arabis*. Figs. 31, 32, 33, 1.

Aculeate, *aculeatus*—bristly with small pointed projections. *Lepidium campestre*. Figs. 61, 2.

Alveolate, *alveolatus*—honeycombed, faveolate, the elevation not rounded off, not sharp. *Cardamine hirsuta*. Figs. 12, 2.

Angustiseptate, *angustiseptatus*—silicles obcompressed, having a very narrow partition, edge of seed faces the partition. *Thlaspi*.

Apex, *apex*—the tip of an organ, opposite the base and frequently narrower than the base.

Apiculate, *apiculatus*—a conspicuous but short point at the apex. *Draba ramorissima*. Fig. 47.

Areolatus, *areolatus*—marked off into little rounded areas by fine lines. *Rorippa sylvestris*. Figs. 21, 2.

Base, *basis*—the extreme of any organ by which it is attached to its support and by which nutrition takes place.

Beveled, *OF. bevel*—a sloped edge or surface, an oblique apex or base. *Hesperis matronalis*. Fig. 81. *Sisymbrium officinale*. Fig. 3-C.

Claw, *AS. clawu*—appendage-like structures at the base of the seed, present when the division between the cotyledons and the radicular ridge cleaves basally. The claws may be straight, curved, or one lying in part upon the other. *Armoracia aquatica*. Fig. 9.

Cleft, *ME cleft*—when the cotyledonary and radicular ridge separate at the base of the seed, leaving a V-shaped area which is usually filled with funicular material. *Erucastrum gallicum*. Fig. 44-A.

Cochleate, *cochleatus*—coiled or shaped like a snail shell. *Carara didyma*. Fig. 86-B.

Colliculate, *colliculus*—rounded broad elevations, closely spaced, covering the seed coat. *Rorippa islandica*. Fig. 20.

Color—when hyphenated as in orange-red, indicates that the basic color could not be determined; without the hyphen as in orange red, the basic color is red, orange being the adjective.

Columnar, *columnaris*—having the shape of a column or pillar, elongated but not circular in cross-section (see terete). *Isatis tinctoria*. Fig. 90-A.

Compressed, *compressus*—pressed together from opposite sides in varying degrees from slightly compressed to strongly compressed. *Lepidium campestre*. Fig. 61. *Lepidium virginicum*. Fig. 40-A.

Concave, *concavus*—with the surface curved in.

Conduplicate, *conduplicatus*—cotyledons folded upon themselves lengthwise, the side of one of the cotyledons lying against the radicular ridge, and both cotyledons folded

about the radicular ridge. Thus the seeds are usually spheroid. *Brassica*. Figs. 67, 68, 69, 1.

Cordiform, *cordiformis*—shaped like a heart. *Rorippa sessiliflora*. Fig. 24.

Coriaceous, *coriaceus*—appearing leathery. *Leavenworthia uniflora*. Fig. 83.

Crena, *crena*—a rounded broad elevation, tooth or notch.

Crenate, *crenatus*—scalloped or with rounded notches around the edge of seed. *Arabis missouriensis*. Fig. 35.

Crenulate, *crenulatus*—like crenate, but the rounded notches small. *Lepidium latifolium*. Fig. 37.

Crest, *OF. creste*—an outgrowth of the funiculus in seeds. Fig. 1.

Cuneate, *cuneatus*—cuneiform or wedge-shaped. *Isatis tinctoria*. Fig. 90-B.

Dehiscent, *dehiscens*—fruits which open spontaneously by valves when ripe. Fig. 1.

Depauperate, *depauperatus*—below the natural size, appearing starved.

Depressed, *depressus*—a slight concavity on a portion of one side of seed. *Rorippa austriaca*. Fig. 23.

Eccentric, *excentricus*—one-sided, out of the main axis. *Thlaspi arvense*. Fig. 58.

Ellipsoid, *Gr. ellipseis & oid*—oblong-like with a flowing outline, the two ends narrowing and nearly alike. *Descurainia pinnata*. Figs. 1, 7.

Face, *facies*—any one of the plane slant surfaces that bound a polyhedron or sub-polyhedral form. *Arabis glabra*. Fig. 26. *Berteroa mutabilis*. Fig. 66-B.

Falsifoveate, *falsus & foveatus*—a pit which does not have the same depth throughout, as a little depression made laterally. *Iodanthus pinnatifidus*. Figs. 34, 2.

Favulariate, *favulariate*—finely ribbed surface separated by zigzag furrows. *Cardamine bulbosa*. Figs. 76-A, 2.

Foveate, *foveatus*—pitted. *Barbarea vulgaris* in part. Figs. 54, 2.

Foveolate, *foveolatus*—marked with little pits. *Rorippa sessiliflora*. Figs. 24, 2.

Funiculus, *funiculus*—the stalk of the seed by which it was attached to the fruit. In the Cruciferae, the funiculus frequently proliferates forming a crest in addition to the stalk proper. Fig. 1.

Furrow, *AS furh*—the longitudinal depressions or channels between the rib of a ribbed surface. *Thlaspi arvense*. Figs. 58, 2.

Glebulate, *glebula*—small clumps of irregularly placed granules. *Cardamine pennsylvanica*. Figs. 14, 2.

Globose, *globosus*—globular, or close to a sphere. *Brassica*. Figs. 68, 69, 70, etc.

Granulate, *granulatus*—slight knob-like elevations on the surface, grain-like in appearance. *Cardaria draba*. Figs. 57, 2.

Groove, *MD. groove*—(a) primary—reserved for the configuration on the outside of the seed which marks the division between the radicular ridge and cotyledons within the seed. Figs. 1, 13. (b) secondary—the configuration on the outside of the seed which marks the division between the two cotyledons when the seed is incumbent. (However, this groove is not always present in incumbent seeds.) Figs. 1, 10. (c) false—not due to the internal anatomy as above, rather produced by the folding and compression of the seed externally. *Diploaxis muralis*. Fig. 29A.

Hilar, *hilum*—close to the hilum or similar to the hilum.

Hilum, *hilum*—the scar on the seed marking its former place of attachment to the fruit. In the Cruciferae the seed does not always sever at this place, rather a part or all of the funiculus remaining. Fig. 1.

Incumbent, *incumbens*—position of the cotyledons when the back of one lies against the radicular ridge (in older textbooks termed dorsal-rooted). Used almost exclusively in the Cruciferae (in the Resedaceae, also). *Capsella bursa-pastoris*. Figs. 10, 1.

Indehiscent, *dehiscens*—not opening, as fruits which remain closed at maturity. *Neslia*

paniculata. Fig. 84-A. There appear to be degrees of indehiscence. In *Cardaria* sp., and *Lunaria* sp. only weakly indehiscent.

Inner side, the side of the seed facing or lying against the septum in the fruit. (Not used for seeds borne in fruits angustiseptally compressed—*Lepidium*, *Cardaria*, *Thlaspi*, *Capsella*, *Iberis*, *Hutchinsia*.) Fig. 1.

Interspace, *inter & spatium*—the depression or area outlined by the reticulum on a reticulate seed coat. *Nasturtium officinale*. Figs. 8, 2.

Interstice, *interstitium*—the depression or area outlined by the elevations on an alveolate coat. *Cardamine hirsuta*. Figs. 12, 2.

Latiseptate, *latiseptatus*—applied to those Cruciferae which have a broad partition in their silicles. *Lunaria*. Fig. 94-B.

Linear, *linearis*—long and narrow, several times longer than wide, uniform in width. *Sisymbrium officinale*. Fig. 3-F.

Lineate, *lineatus*—marked with fine lines. *Thlaspi perfoliatum*. Figs. 22, 2.

Lineolate, *lineolatus*—marked with broken fine lines. *Arabis canadensis*, the outer band or wing. Figs. 56, 2.

Marginate, *marginatus*—a margin of distinct character. *Cardamine pennsylvanica*. Figs. 14, 2.

Mitiform, *mita*—mitten-shaped. *Camelina Parodii*. Figs. 52, 1.

Mottled, *ME moteley*—marked with spots or lines of a different color from the seed coat background. *Cardamine pennsylvanica*. Figs. 14, 2.

Obliquely incumbent—intermediate between incumbent and accumbent, but closer to incumbent. *Sisymbrium officinale*. Figs. 3, 1.

Oblong, *oblongus*—much longer than broad with nearly parallel sides. *Erysimum repandum*. Figs. 62, 1.

Obovate, *ob & ovum*—reversed ovate, broadest at apex, in outline and not a solid.

Obovoid, *ob & ovum*—inversely ovoid, or like an obovate solid, wider at the apex than the base. *Lepidium campestre*. Figs. 61, 1.

Obtuse, *obtusus*—blunt, or rounded at the end.

Ocellate, *ocellatus*—a little eye, with a circular area around it. *Conringia orientalis*. Figs. 78, 2.

Orbicular, *orbicularis*—a somewhat flat body with a circular outline. *Berteroa incana*. Figs. 64, 1.

Outer side—the side of the seed facing the valve of the fruit. (Not used for seeds borne in fruits angustiseptally compressed—*Lepidium*, *Cardaria*, *Thlaspi*, *Capsella*, *Iberis*, *Hutchinsia*.) Fig. 1.

Oval, *ovalis*—broadly ellipsoid with the breadth considerably more than half the length. *Cardamine hirsuta*. Figs. 12, 2.

Ovate, *ovatus*—shaped like an egg with the broader end at the base, or ovate in outline.

Ovoid, *ob & ovum*—ovate in solid form, or an egg-shaped solid. *Neslia paniculata*, the seed. Fig. 84-B.

Pit, *AS. pytt* which is probably from *L. puteus*—a small surface depression or hollow in which the areas between the hollows do not take on the appearance of a true reticulum net. These areas are either wider or not as sharply delimited as a reticulum. *Rorippa sessiliflora*. Figs. 24, 2.

Plane, *planus*—with a flat, not curved surface.

Polyhedron, *Gr. polyhedros*—having many sides or faces. *Arabis glabra*. Fig. 26.

Pulvinate-depressed, *pulvinatus*—shaped like a cushion, referring to the depression on one side of the seed. Mitiform seeds are frequently pulvinate-depressed. *Camelina Parodii*. Fig. 52.

Punctate, *punctatus*—marked with dots with the appearance of a pencil mark, scarcely an elevation and variously scattered on the seed. *Lesquerella gracilis*. Figs. 45, 2.

Puncticulate, *puncticulatus*—minutely punctate, the surface of seeds that are almost smooth. *Sisymbrium loeselii*. Figs. 5, 2.

Pusticulate, *pustula*—small broad slight elevations, not as high or abundant as the colliculate condition, not having as abrupt elevations as the minutely tuberculate condition. *Draba cuneifolia*. Figs. 18, 2.

Radicular ridge, *radicalis*—pertaining to the radicle. Used for the hypocotyl tissues also. Fig. 1.

Reniform, *reniformis*—kidney- or bean-shaped. *Lunaria annua*. Fig. 94-A.

Replum, *replum*—frame-like placenta from which the valves fall away in dehiscence. It is frequently used to include the septum or false partition of the Cruciferae. Fig. 1.

Reticulate, *reticulatus*—a seed coat with a reticulum or net and interspaces. The true reticulum is an elevation on the seed coat, narrow and sharply angled, frequently presenting a geometric appearance. *Nasturtium officinale*. Figs. 8, 2.

Reticulate-foveate—a border-line condition between reticulate and foveate. *Descurainia pinnata*. Figs. 7, 2.

Reticulate-foveolate—a border-line condition between reticulate and foveolate. *Rorippa obtusa*.

Reticulum, *reticulum*—the net or elevation of a reticulate pattern, its counterpart being the interspaces. *Nasturtium officinale*. Figs. 8, 2.

Ribbed, *A.S. rib*—possessing narrow longitudinal ridges or raised strips with intervening furrows. *Thlaspi arvense*. Figs. 58, 2.

Rough, *A.S. rub*—reserved for seed coats that reveal no organization of markings. This condition is frequent on parts of the coats when seed coat differentiation is not complete although the seed may be mature (viable). *Hesperis matronalis*. Fig. 81.

Ruga, *ruga*—a wrinkle or fold.

Rugose, *rugosus*—wrinkled, the elevations making up the wrinkles, irregular in themselves, running for the most part in one direction. *Coronopus procumbens*. Figs. 88-A, 2.

Rugulose, *rugulosus*—very small wrinkles and frequently only on part of the seed coat.

Ruminate, *ruminatus*—penetrated with irregular channels giving an eroded appearance, the incuts going in different directions. *Dentaria* and *Cardamine* sp. depending upon environmental conditions at the time of ripening. Fig. 2.

Samara, *samara*—an indehiscent winged fruit. *Isatis tinctoria*. Fig. 90-B.

Scalariform, *scalariformis*—small cross-band markings resembling the steps of a ladder. *Descurainia Sophia*. Figs. 6, 2.

Scrobiculate, *scrobiculatum*—an elongated shallow pit. *Barbarea verna* in part. Fig. 53.

Silique, *siliquea*—a common type of fruit among the Cruciferae, being pod-like, longer than broad and dehiscent by two valves. The two valves fall away from a frame—the 'replum' on which the seeds grow, and across which a false partition is formed.

Spheroid, *OF. espere*—like a sphere but not perfectly spherical. *Brassica campestris*. Fig. 71.

Stigmaticose, *stigmaticosus*—full of points or marks; the microscopic marks on the seed surface of the genus *Brassica* both in the interspaces and on the reticulum. *Brassica campestris*. Fig. 71.

Striae, *striae*—minute grooves, thread-like lines.

Striate, *striatus*—marked by a series of fine narrow parallel bands. (A band being wider than the lines in a lineate structure.) *Sisymbrium officinale*. Figs. 3-A, 2.

Subglobose—nearly globular. *Raphanus sativus*. Fig. 85.

Suborbicular, a flat body with an almost circular body, some part of the circumference being irregular. *Rorippa austriaca*. Fig. 23.

Sulcate, *sulcatus*—grooved or furrowed in the form of a "V." *Cardamine bulbosa*. Figs. 73-E, 2.

Terete, *teres*—circular in transverse section, cylindric, may or may not be tapering. *Isatis tinctoria*. Fig. 90-A.

Trapezoidal, *Gr. trapeza*—shaped like a trapezoid with two nearly parallel sides and two beveled sides. *Sisymbrium officinale*. Fig. 3-G.

Truncate, *truncatus*—ending abruptly as though cut off transversely at either apex or base. *Erysimum repandum*. Fig. 62.

Tubercle, *tuberculum*—a small knob-like projection or excrescence.

Tuberculate, *tuberculatus*—small smooth rounded projections or knobs on the seed coat. *Camelina Parodii*. Figs. 52, 2.

Turbinate, *turbinatus*—shaped like a top. *Lesquerella globosa*. Fig. 48.

Twisted conical, *Fr. conique*—in the shape of a cone with the radicular ridge twisted. *Erysimum cheiranthoides*. Fig. 50-D.

Vernicose, *vernicosus*—surface appearing as if varnished or polished. *Sisymbrium Irio*.

Verruca, *verruca*—an irregular projection or knob on the seed coat similar to a wart.

Verrucate, *verrucatus*—covered with irregular projections or knobs; warty. *Cochlearia officinalis*. Figs. 39, 2.

Verruculate, *verruculatus*—covered and closely spaced with tiny verrucae.

Wing, *ON. vaenger*—a thinner expansion attached to the seed, completely or incompletely surrounding the seed. A membranous wing. *Arabis canadensis*. Fig. 56. A coriaceous thicker wing. *Berteroa incana*. Fig. 64.

KEYS FOR IDENTIFICATION

For the general morphology of cruciferous seeds see the chapter "Seed Morphology and Classification of the Cruciferae."

The terms are used as defined in the above terminology. Descriptions apply to mature seeds in which the differentiation of seed coat may or may not be complete. If stated "ocellate, alveolate in part," the interpretation should be: the ocellate condition is found in the final state of seed coat maturation, the alveolate condition in an earlier state of differentiation. Apex and base refer to the seed only (see terminology) and not to its orientation within the fruit. The seed is usually pendulous within the fruit, in which case the seed is oriented with the base of the seed toward the apex. There are exceptions; therefore for the sake of uniformity all seeds have been drawn with the apex toward the top of the page. When the seed is isolated from the fruit, the outer and inner sides of the seed usually cannot be determined. If these two sides are different they are both described and referred to as "inner" and "outer" rather than stating "one side of the seed and the other side." Since seed characters are being considered not only as isolated structures but also in the broader field of plant taxonomy such terms are retained in the keys and descriptions.

Observations on seed coat organization were made and drawn at magnifications of approximately 45. Magnifications as high as 60 were frequently used to confirm observations made at 45x.

In the descriptions four main characters are considered and separated by semi-colons: dimensions: shape: color: seed coat. When possible this order has been used in the key. Additional special diagnostic characters are also

used such as type of wing, a prominent beak, etc. To insure a rapid identification of "unknowns," not all of the above characters are always used for each specific seed, only those highly diagnostic being retained in the keys.

For convenience in running identifications the species were divided into two keys: seeds from dehiscent and indehiscent fruits. However, borderline cases in the degree of dehiscence occur. *Cardaria* sp. usually treated as indehiscent appear in Key I for the reason that the seeds isolated from the fruit are found in seed samples. *Raphanus sativus* appears in both keys. Key II includes the strongly indehiscent fruits with the exception of *Raphanus sativus* and *Lunaria* sp.

The range of dimensions are given in the key. (both range and median in the descriptions).

Unless otherwise stated length, width, thickness, seed coat, color and shape refer to the entire seed.

The descriptions of the species in the keys represent the most typical seed studied. Since the key is abbreviated as much as possible, the full taxonomic descriptions should be used in order to identify correctly highly variable seeds. Studies of mass collections (see that chapter) provided considerable evidence that seed characters in this family are frequently quite variable. Consequently, the construction of workable keys is beset with difficulties.

For the convenience of those using *Gray's Manual* (Fernald, 1950) the nomenclature used in this paper conforms essentially with the new manual. A few exceptions will be found in the case of citation of authors and in the *Brassica* species.

SEED CHARACTERS OF GENERIC IMPORTANCE IN THE CRUCIFERAE

Presence of a membranous wing; cotyledons accumbent	<i>Arabis</i>
Reticulate-foveate; metallic color; cotyledons obliquely incumbent	<i>Barbarea</i>
Presence of a coriaceous wing; 2 mm. or less in length; orbicular or short oblong; cotyledons accumbent	<i>Berteroa</i>
Reticulate or alveolate seed coat; globose to sub-globose; cotyledons conduplicate	<i>Brassica</i>
Seeds borne in indehiscent fruits; seed shape cochleate; cotyledons incumbent and folded transversely	<i>Coronopus</i>
Seed coat ruminant or rugose; cotyledons petioled, their margins infolding, bent occurring above the cotyledonary node, accumbent	<i>Dentaria</i>
Orbicular, flat; coriaceous wing; over 2 mm. in length; embryo nearly straight, not truly accumbent	<i>Leavenworthia</i>
Sub-globose, tri-ridged; alveolate; cotyledons conduplicate	<i>Raphanus</i>
Seeds borne in dehiscent fruits; cotyledons incumbent and folded transversely	<i>Subularia</i>

SEED KEYS TO THE CRUCIFERAE OF NORTHEASTERN NORTH AMERICA

I. Key to Seeds from Dehiscent Fruits

1. Seed globose or sub-globose; seed coat reticulate or alveolate; cotyledons always conduplicate 2
1. Seed not globose or sub-globose; seed coat variously developed; cotyledons mostly incumbent or accumbent 8

2. Seed sub-globose to sub-oblong, slightly flattened, tri-ridged; alveolate; length 3.0-3.5 mm., width 3.0-3.4 mm.91. *Raphanus sativus*¹ (Fig. 85)
2. Seed globose to sub-globose, not tri-ridged; reticulate or alveolate; diameter 3.0 mm. or less 3
3. Diameter 3.0 mm.; alveolate to rugulose; light yellow82. *Brassica hirta*² (Fig. 67)
3. Diameter less than 2.0 mm. 4
4. Alveolate, velvety appearance under low magnifications; spheroid84. *Brassica kaber* (Fig. 72)
4. Reticulate 5
5. Distinctly stigmaticose 6
5. Indistinctly stigmaticose in the interspaces only 7
6. Interspaces larger81. *Brassica campestris* (Fig. 71)
6. Interspaces smaller81a. *Brassica campestris* var. *rapa* (Fig. 70)
7. Interspaces larger; reticulum 4-5 sided with netting in the interspaces83. *Brassica juncea* (Fig. 68)
7. Interspaces smaller and deeper; reticulum 5-6 sided, thicker; markings not well defined in the interspaces85. *Brassica nigra* (Fig. 69)
8. Seed symmetrical; usually not obliquely or laterally compressed (Except conduplicate seeds of *Erucastrum*, *Eruca*, and *Diplotaxis*) 9
8. Seed asymmetrical; frequently obliquely or laterally compressed: either concave to pulvinate-depressed, some with claws not in the same plane or transversely and longitudinally ridged, twisted angular, polyhedral, columnar or terete. (Seeds of the following species are variable in shape and sometimes are symmetrical and flat. *Sisymbrium altissimum*, *S. officinale*, *Erysimum asperum*, *E. cheiranthoides*, *Diplotaxis* sp.) 95
9. Seed slightly compressed, hemispherical, oblong, beveled, ellipsoid, columnar, or obovoid; without wing; length 1.1-3.0 mm. 10
9. Seed strongly compressed sometimes wafer-like; with or without wing 23
10. Oblong or hemispherical; seed coat alveolate; orange-red³ to red 11
10. Oblong, oblong-beveled, obovoid, oval, ellipsoid, columnar; seed coat otherwise or only in part alveolate 13
11. Oblong; alveolate; length 1.0-1.3 mm., width 0.6-0.8 mm. 12
11. Hemispherical on outer side, sometimes two beveled faces on inner side; granulate to globulate; length 1.2-1.3 mm., width 1.1-1.3 mm.116. *Lesquerella globosa* (Fig. 48)
12. Alveolate with elongate interspaces; seeds in water form only a slight mucilaginous envelope; cotyledons conduplicate87. *Erucastrum gallicum* (Fig. 44)
12. Alveolate in early stages of differentiation becoming verrucate; seeds in water form a conspicuous striated mucilaginous envelope; cotyledons incumbent109. *Camelina microcarpa* (Fig. 42)
13. Seed coat ocellate or rough 14
13. Seed coat otherwise 15
14. Ocellate in part alveolate; oblong; brownish red; length 1.0-2.5 mm., width 1.0-1.5 mm., thickness 1.5 mm.92. *Conringia orientalis* (Fig. 78)
14. Rough, alveolate and ocellate; oblong, beveled, ellipsoid, columnar; inner side flat, outer side transversely ridged; wing frequently present at base

¹ Not distinctly dehiscent but commercially the seed appears without the fruit.

² For a more detailed key to *Brassica* species see Musil (1948).

³ See "color" in Terminology: a color when hyphenated indicates that the basic color could not be determined.

- and apex; reddish-brown; length 2.1-3.0 mm., width 1.0-1.3 mm., thickness 0.9-1.1 mm.57. *Hesperis matronalis* (Fig. 81)
15. Obovoid, slightly angled, pointed at base, radicular ridge conspicuous as a wide wedge; red to grayish black; tuberculate and aculeate; length 2.0-2.1 mm., width 1.1-1.3 mm.93. *Lepidium campestre* (Fig. 61)
15. Oval, oblong or oblong and slightly transversely ridged, slightly compressed 16
16. Length 1.6 mm. or less 17
16. Length 1.7-2.9 mm. 21
17. Verrucate, alveolate in part 18
17. Favariate, punctulate or areolate-scalariform 19
18. Verrucae irregular at apex; length 1.1-1.6 mm., width 0.9-1.0 mm.106. *Cochlearia officinalis* (Fig. 39)
18. Verrucae irregular at base; length 1.0-1.2 mm., width 0.6-0.7 mm.109. *Camelina microcarpa* (Fig. 42)
19. Slightly transversely ridged; yellow; length 0.8-1.1 mm., width 0.5 mm.2. *Sisymbrium altissimum* (Fig. 4)
19. Not transversely ridged 20
20. Minutely favariate, punctulate to almost smooth, greasy appearance; length 0.8-1.1 mm., width 0.5 mm.2. *Sisymbrium altissimum* (Fig. 4)
20. Areolate-scalariform; base truncate, frequently notched, two funicular appendages; length 0.8-1.0 mm., width 0.3-0.5 mm., thickness 0.25 mm.113. *Capsella bursa-pastoris* (Fig. 10) or 114. *Capsella rubella*
21. Length 2.7-2.9 mm., width 1.4-1.7 mm.; areolate; oval slightly eccentric; primary groove deep, secondary groove indistinct and forked; reddish-orange98. *Lepidium sativum* (Fig. 60)
21. Length 1.7-1.9 mm.; granulate or reticulate-areolate 22
22. Oval, flat; cleft; granulate; red; width 1.1-1.3 mm., thickness 0.5 mm.100. *Cardaria Draba* (Fig. 57) or 101. *Cardaria pubescens*
22. Oval-oblong somewhat rounded contour; reticulate-areolate; orange or gray; two black lines running parallel to the primary groove; width 1.2-1.4 mm., thickness 0.6-0.7 mm.; cotyledons conduplicate86. *Eruca sativa* (Fig. 79)
23. Wing absent 24
23. Wing present, membranous or coriaceous 65
24. Length less than 1.5 mm., width less than 1 mm. (Exception *Erysimum inconspicuum* may be longer) 25
24. Length 1.5 mm. or over, width 1.0 mm. or over 58
25. Seed opaque 26
25. Seed translucent and glassy in appearance; oblong, broadly oval or ellipsoid; light red, light yellow, orange, frequently patterned in red 54
26. Primary groove lateral (indistinct in *Hutchinsia procumbens*) 27
26. Primary groove central in position or nearly so 52
27. Length 0.5 mm. or less; broadly oblong or broadly oval 28
27. Length 0.6 mm. or over; width 0.3 mm. or over; oval 29
28. Primary groove indistinct or absent; length 0.4-0.5 mm., width 0.3-0.4 mm.; punctulate; base of seed red104. *Hutchinsia procumbens* (Fig. 25)
28. Primary and secondary grooves distinct; length 0.35-0.4 mm., width 0.2 mm.; verrucate and areolate36. *Arabidopsis Thaliana* (Fig. 30)
29. Length 0.6 mm., width 0.3-0.4 mm.; punctulate, areolate 30
29. Length 0.7 mm. or over 31

30. Oval, rounded at apex; punctulate; yellow
77. *Draba reptans* (Fig. 18), 75. *Draba nemorosa*, 78. *Draba verna*
30. Ovoid-oval, pointed at apex; areolate; yellow, darker in color at the edges
70. *Draba brachycarpa* (Fig. 19)
31. Seed coat rough, granulate, pustulate or punctulate; oval, sub-oval, narrowly
 obovoid, or ovoid 32
31. Seed coat otherwise (or if rough or punctulate as in *Arabis dentata* and *Sisymbrium loeselii*), oblong or ellipsoid and thicker 37
32. Length 0.7-1.1 mm. 33
32. Length over 1 mm., punctulate, granulate, or rough 34
33. Punctulate; length 0.7-1.0 mm.74. *Draba lanceolata*
33. Pustulate71. *Draba cuneifolia* (Fig. 16)
34. Punctulate; length 1.0-1.6 mm.; sub-polyhedral69. *Draba arabisans*
34. Granulate or rough 35
35. Funicular appendages present72. *Draba fladnizensis*
35. Funicular appendages absent 36
36. Hilar area banded76. *Draba ramosissima* (Fig. 47)
36. Hilar area not banded73. *Draba glabella*
37. Primary groove deep in all or part of its length 38
37. Primary groove shallow 47
38. Base on the cotyledonary side flat appearing as an appendage; three grooves;
 radicular ridges longer than cotyledons; deep cleft; length 1.2-1.5 mm.,
 width 0.6-0.7 mm.60. *Braya Longii*
38. Base on the cotyledonary side not flat 39
39. Orbicular or ellipsoid 40
39. Obovoid, oblong or ovoid 43
40. Orbicular; reticulate, sharp angled, 4-5 sided, interspaces wide; orange-red;
 length 0.9-1.1 mm., width 0.8-0.9 mm.23. *Nasturtium officinale* (Fig. 8)
40. Ellipsoid 41
41. Wide depression on the inner side of the entire seed 42
41. No depression on the inner side; scalariform; bright orange; length 0.8-0.9 mm.,
 width 0.4 mm.8. *Descurainia Sophia* (Fig. 6)
42. Reticulate-foveate; brownish red; length 0.9-1.1 mm., width 0.4-0.5 mm.
6. *Descurainia pinnata* (Fig. 7)
42. Reticulate-areolate, alveolate and scalariform in part; length 1.0-1.1 mm.,
 width 0.5-0.7 mm.7. *Descurainia Richardsonii*
43. Narrowly obovoid, plump, deep groove one-third length of the seed; glebulate;
 length 1.3-1.4 mm., width 0.7 mm.97. *Lepidium ruderales* (Fig. 38)
43. Oblong or ovoid 44
44. Oblong; favulariate, minutely tuberculate, granulate or areolate 45
44. Ovoid, frequently eccentric at apex and on radicular side; reticulate-areolate;
 wing at apex; length 1.4-2.0 mm., width 0.7-0.9 mm.
11. *Erysimum inconspicuum* (Fig. 63)
45. Favulariate, minutely tuberculate at periphery; length 1.0-1.1 mm., width 0.5-0.6
 mm.95. *Lepidium latifolium* (Fig. 37)
45. Granulate or areolate; truncate at base 46
46. Minutely granulate; truncate at base, sometimes at apex; emarginate; length
 1.1-1.3 mm., width 0.7 mm.12. *Erysimum repandum* (Fig. 62)
46. Areolate, scalariform in part; base truncate, notched, with two funicular

- appendages; orange yellow, darker at base; length 0.8-1.0 mm., width 0.3-0.5 mm., thickness 0.25 mm.113. *Capsella bursa-pastoris* (Fig. 10) or 114. *Capsella rubella*
47. Oblong or narrowly oval 48
47. Obovoid; almost smooth to lineolate; frequently conspicuously emarginate on some of the edges; length 1.0-1.3 mm., width 0.6-1.0 mm.108. *Thlaspi perfoliatum* (Fig. 22)
48. Rough, scalariform or areolate 49
48. Smooth to punctulate 51
49. Beak present; radicular ridge one-third the width of seed 50
49. Beak absent; areolate; one claw longer than the other; primary groove obscure; length 0.7 mm., width 0.5 mm.22. *Rorippa sylvestris* (Fig. 21)
50. Beak curving toward cotyledons; rough; dark orange; darker line around periphery of seed, frequently emarginate; length 1.0-1.1 mm., width 0.5-0.7 mm.49. *Arabis perstellata*
50. Beak and cotyledons same length, base of cotyledons flattened and darker; reticulate-areolate, scalariform in part; wing, if present, only at apex and very narrow; length 0.7-0.9 mm., width 0.5 mm.46. *Arabis lyrata* (Fig. 28)
51. Smooth, vernicose; pure yellow; hilar area outlined in red; length 0.8-0.9 mm., width 0.4-0.5 mm.3. *Sisymbrium irio*
51. Smooth in part, punctulate; hilar area elongate; length 0.8-0.9 mm., width 0.5 mm.4. *Sisymbrium loeselii* (Fig. 5)
52. True primary groove; secondary groove evident 53
52. False primary groove, a fold; secondary groove absent or obscure; oval, or narrowly obovoid; one claw lying in part upon another; striate; length 1.0-1.2 mm., width 0.8-0.9 mm.79. *Diploxys muralis* (Fig. 29B)
53. Secondary groove deep, present on the cotyledonary side and part of the radicular side caused by the transversely folded incumbent cotyledons; angular on one side to cochleate; length 0.9-1.1 mm., width 0.7-0.8 mm.115. *Subularia aquatica* (Fig. 17)
53. Secondary groove shallow, running parallel with primary groove; oblong, truncate at base, frequently notched; funicular material in notch or in the form of two pointed projections from claws; areolate and scalariform; length 0.8-1.0 mm., width 0.3-0.5 mm., thickness 0.25 mm.113. *Capsella bursa-pastoris* (Fig. 10) or 114. *Capsella rubella*
54. Oblong to broadly oval 55
54. Ellipsoid, cotyledonary base thin, appearing as a darker appendage; three grooves; cleft and crest prominent59. *Braya humilis* (Fig. 15)
55. Reticulate-areolate or areolate; oblong; beak curving toward cotyledonary side of seed 56
55. Alveolate or glebulate and lineate; broadly oval 57
56. Reticulate-areolate; length 0.7-0.9 mm., width 0.4-0.6 mm.29. *Cardamine parviflora* (Fig. 11)
56. Areolate; length 1.1-1.2 mm., width 0.5 mm.31. *Cardamine pratensis* (Fig. 13)
57. Alveolate; narrow wing on some edges; length 1.0-1.1 mm., width 0.7-0.8 mm.28. *Cardamine hirsuta* (Fig. 12)
57. Glebulate, superimposed upon a lineate background; emarginate30. *Cardamine pennsylvanica* (Fig. 14), 32. *Cardamine rotundifolia*
58. Seed coat ribbed 59
58. Seed coat not ribbed 61

59. Ribs dichotomously branched; ellipsoid; length 2.6-3.6 mm., width 0.9-1.1 mm.
.....50. *Alliaria officinalis* (Fig. 55)
59. Ribs not dichotomously branched 60
60. Ribs wide, concentrically arranged at the periphery becoming parallel at the center; furrows transversely lineate; seed broadly oval; length 1.8-2.0 mm., width 1.1-1.4 mm.107. *Thlaspi arvense* (Fig. 58)
60. Ribs very narrow, similar to fine raised lines, longitudinal, irregular, sometimes anastomosing; seed elongate-oval; dark brown; length 1.9-2.1 mm., width 0.7-1.0 mm.26. *Cardamine Clematis*
61. Shape mitiform 62
61. Shape not mitiform; favulariate, ruminant, rugose, sulcate; green-yellow to dark orange 63
62. Seed coat granulate, alveolate in part; radicular ridge narrow; length 1.4-2.0 mm., width 1.0-1.4 mm.118. *Lesquerella ludoviciana* (Fig. 46)
62. Seed coat punctate; radicular ridge wider; length 1.6-2.0 mm., width 1.1-1.6 mm.117. *Lesquerella gracilis* (Fig. 45)
63. Seed thick, laminate; squarish or ovoid; length 1.9-2.7 mm., width 1.9-2.2 mm.33. *Dentaria laciniata* (Fig. 75)
63. Seed flatter, not laminate; sub-rectangular, sub-orbicular, oval, elongate-oval 64
64. Variable in shape; emarginate in part; length 1.7-2.1 mm., width 1.1-1.5 mm.25. *Cardamine bulbosa* (Fig. 73) or 27. *Cardamine Douglassii*
64. Broadly oval, truncate at base, eccentric on cotyledonary side at apex; groove evident but not deep; length 1.4-1.7 mm., width 0.9-1.2 mm.24. *Cardamine bellidifolia*
65. Wing membranous 66
65. Wing coriaceous; seed of coarse texture, buckled on drying 91
66. Wing width 0.15 mm. or less 67
66. Wing width over 0.15 mm. in widest parts 83
67. Wing surrounding seed 68
67. Wing not completely surrounding seed; length 1.0-3.0 mm., width 2.0 mm. or less 75
68. Wing thicker, not transparent; obovoid or oval; minutely tuberculate; length 1.5-1.7 mm., width 1.1-1.2 mm.67. *Alyssum alyssoides* (Fig. 49)
68. Wing thinner, frequently transparent 69
69. Wing reduced on either radicular or cotyledonary side 70
69. Wing not reduced; seed coat reticulate-areolate to favulariate 71
70. Wing reduced on radicular side, frequently absent; granulate; length 1.0-1.5 mm., width 0.9-1.1 mm.68. *Lobularia maritima* (Fig. 43)
70. Wing frequently reduced on cotyledonary side; blackish brown line curving in the form of a hook; length 1.9-2.1 mm., width 1.1-1.3 mm.96. *Lepidium perfoliatum* (Fig. 41)
71. Oval to orbicular; wing of relatively uniform width 72
71. Oblong to oval; wing widest at apex 74
72. Conspicuous brownish black line curving in the form of a hook; oval; length 1.9-2.1 mm., width 1.1-1.3 mm.96. *Lepidium perfoliatum* (Fig. 41)
72. Brownish black line lacking; broadly oval to orbicular 73
73. Reticulate-areolate; seed proper frequently oriented at a slight angle in wing; length 1.1-1.5 mm., width 0.8-1.3 mm.52. *Sibara virginica* (Fig. 27)
73. Reticulate-areolate and favulariate; cleft deeper; hilum more conspicuous; length 1.1-1.3 mm., width 0.9-1.0 mm.37. *Arabis alpina*

74. Bright yellow; length 1.1-1.7 mm., width 0.6-0.9 mm.48. *Arabis patens*
 74. Dark yellow to brown; length 1.1-1.2 mm., width 0.7 mm.43. *Arabis hirsuta*
 75. Wing present at apex or base or both 76
 75. Wing absent on either cotyledonary or radicular edges 79
 76. Wing present at apex 77
 76. Wing present at apex and base; burnished red; broadly oblong; falsifoveate; length 1.0-1.5 mm., width 0.8-1.0 mm.56. *Iodanthus pinnatifidus* (Fig. 34)
 77. Greenish brown; areolate-scalariform, rough in part; oblong; cleft; length 2.0-2.3 mm., width 1.0 mm.1. *Stanleya pinnata* (Fig. 80)
 77. Dark orange to red; darker cotyledonary base 78
 78. Granulate; narrowly oval; length 1.7-2.0 mm., width 0.8 mm.9. *Erysimum asperum* (Fig. 65)
 78. Areolate; ellipsoid, oval, oblong; length 1.0-1.4 mm., width 0.5-0.6 mm.10. *Erysimum cheiranthoides* (Fig. 50)
 79. Wing absent on all or part of the cotyledonary edge 80
 79. Wing absent on radicular edge; granulate; length 1.0-1.5 mm., width 0.9-1.1 mm.68. *Lobularia maritima* (Fig. 43)
 80. Length 1.6 mm. or over; deep orange; areolate 81
 80. Length 1.4-1.6 mm., width 0.9-1.0 mm.; narrowly obovate to oval; light orange; minutely tuberculate; wing width 0.1 mm. or less; flat, wafer-like 82
 81. Wing wider and pointed at apex; lineolate; cleft; length 2.1-3.0 mm., width 1.4-2.0 mm.105. *Iberis amara* (Fig. 76)
 81. Wing absent on part of cotyledonary side; reticulate-areolate; length 1.2-1.6 mm., width 0.8-1.0 mm.40. *Arabis divaricarpa* (Fig. 32)
 82. Cotyledons accumbent99. *Lepidium virginicum* (Fig. 40)
 82. Cotyledons incumbent94. *Lepidium densiflorum*
 83. Wing surrounding seed 84
 83. Wing not completely surrounding seed, banded in part; seed oval to ovoid; reticulate-areolate with wide interstices; hilum banded; length 1.2-1.6 mm., width 0.8-1.0 mm.40. *Arabis divaricarpa* (Fig. 32)
 84. Wing ruffled or scalloped and banded 85
 84. Wing not ruffled or scalloped 87
 85. Bands obscure; seed orbicular to broader than long; granulate; length 1.4-2.0 mm., width 1.7-2.1 mm.58. *Matthiola incana* (Fig. 74)
 85. Bands well defined 86
 86. Inner band orange, reticulate-areolate; outer band yellow, lineolate39. *Arabis canadensis* (Fig. 56)
 86. Inner band yellow, glebulate; outer band white, punctulate, scalloped; seed coat proper ruminate, alveolate, glebulate47. *Arabis missouriensis* (Fig. 35)
 87. Wing banded in part 88
 87. Wing not banded 89
 88. Wing banded largely on radicular side and apex; orbicular; variegated44. *Arabis Holboellii* (Fig. 33)
 88. Wing banded apically or bands obscure to absent; oval; groove deep, irregular; hilar area double-banded; length 2.2-3.0 mm., width 1.4-1.7 mm.55. *Cheiranthus Cheiri* (Fig. 77)
 89. Oval or oblong 90
 89. Orbicular; seed coat granulate; wing reticulate-areolate; hilar area banded; length seed proper 0.9-1.3 mm., width 0.9-1.3 mm., wing width 0.15 to 0.2 mm.41. *Arabis Drummondii* (Fig. 31)

90. Oval (See 88)55. *Cheiranthus Cheiri* (Fig. 77)
90. Oblong; seed coat and wing reticulate-areolate; length seed proper 1.1-1.5 mm., width 0.8-1.1 mm.45. *Arabis laevigata* (Fig. 59)
91. Length less than 2 mm.; wing width 0.15-0.2 mm., rim-like, frequently absent on some of the edges 92
91. Length over 2 mm.; wing width 0.3-0.5 mm., or difficult to delimit from seed coat proper 93
92. Brown with a hoary cast; wing thinner; orbicular, occasionally sub-oblong; length 1.7-1.9 mm., width 1.4-1.7 mm.65. *Berteroa incana* (Fig. 64)
92. Dark reddish brown; wing thicker and narrower; ovoid and orbicular; beveled faces on outer side; length 1.3-1.5 mm., width 1.1-1.3 mm.66. *Berteroa mutabilis* (Fig. 66)
93. Cleft empty, seed proper orange, wing yellow; reticulate, interspaces wider on wing than seed coat; length 2.7-3.1 mm., width 2.4-2.9 mm., cotyledons accumbent62. *Selenia aurea* (Fig. 82)
93. Cleft with crest; seed proper dark brown, wing orange; reticulate, interspaces smaller, uniform on wing and seed coat; embryo nearly straight, not truly accumbent 94
94. Wing distinct from seed proper, width 0.3-0.5 mm.; orbicular; length 2.5-3.4 mm., width 2.5-3.0 mm.35. *Leavenworthia uniflora* (Fig. 83)
94. Wing and seed proper merging imperceptibly in places; oblong or orbicular; length 2.4-2.8 mm., width 1.9-2.2 mm.34. *Leavenworthia torulosa*
95. Pulvinate-depressed, columnar, twisted, and highly ridged 96
95. Shape otherwise112
96. Pulvinate-depressed 97
96. Twisted, ridged transversely or longitudinally, columnar-linear, occasionally flattened. (Seeds of the same species may be variable in shape.)106
97. Yellow, orange, white 98
97. Metallic or grayish-brown; reticulate-foveate105
98. Mitiform, cordiform or angular 99
98. Sub-orbicular or angular; one or both claws pointed104
99. Mitiform; orange; tuberculate; length 2.4-2.6 mm., width 2.0-2.5 mm., cotyledons accumbent110. *Camelina Parodi* (Fig. 52)
99. Cordiform100
100. Colliculate or ocellate101
100. Foveolate, reticulate-foveolate103
101. Colliculate, lustrous102
101. Ocellate, reticulate and crenose in part; sub-lustrous; angular21. *Rorippa sinuata*
102. Yellow, length 0.5-0.8 mm., width 0.5 mm.18. *Rorippa islandica* (Fig. 20)
102. White; length 0.5-0.6 mm., width 0.5 mm.17. *Rorippa curvisiliqua*
103. Foveolate; little or no cuticle; light tan; length 0.4-0.45 mm., width 0.4 mm.20. *Rorippa sessilisiflora* (Fig. 24)
103. Reticulate-foveate; cuticle abundant; yellow; length 0.5-0.6 mm., width 0.4-0.5 mm.19. *Rorippa obtusa*
104. Minutely tuberculate, reticulum superfluous and sloughing off; length 0.5-0.7 mm., width 0.4-0.5 mm.13. *Armoracia aquatica* (Fig. 9)
104. Reticulate; depressed on inner side with several faces, frequently angular in shape; claws may or may not be in the same plane; length 0.7-0.8 mm., width 0.6-0.7 mm.16. *Rorippa austriaca* (Fig. 23)

105. Orbicular; length 1.0-1.4 mm., width 0.9-1.3 mm.15. *Barbarea vulgaris* (Fig. 54)
105. Oblong or orbicular; scrobiculate in part; length 1.4-2.1 mm., width 0.9-1.4 mm.
.....14. *Barbarea verna* (Fig. 53)
106. Tuberculate or granulate; length 1.7 mm. or over107
106. Alveolate, glebulate, areolate, punctulate, striate; length 1.5 mm. or less
.....108
107. Tuberculate; twisted ovoid or flat; length 2.1-2.6 mm., width 1.0-1.4 mm., cotyledons incumbent111. *Camelina sativa* (Fig. 51)
107. Granulate; columnar, twisted, ellipsoid; wing at apex; cotyledonary base rough and black; length 1.7-2.0 mm., width 0.8 mm.9. *Erysimum asperum* (Fig. 65)
108. Depression along side primary groove or two deep grooves; alveolate, areolate, or finely irregularly ribbed in part; orange; wing may be present109
108. Depressions or grooves not as prominent; favulariate, punctulate, striate, greasy in appearance; orange, gray-yellow, yellow, olive green; wing tip rarely present110
109. Depression along side of primary groove; alveolate and glebulate; wing tip frequent; length 1.2-1.5 mm., width 0.5-0.6 mm.38. *Arabis arenicola* (Fig. 36)
109. Two deep grooves; finely irregularly ribbed; wingless; length 1.0-1.2 mm., width 0.4-0.5 mm.51. *Halimolobos mollis*
110. Hilar area black, otherwise orange; areolate, sometimes punctulate to minutely tuberculate; variable in shape; length 1.0-1.4 mm., width 0.3-0.5 mm.; cotyledons incumbent or obliquely incumbent10. *Erysimum cheiranthoides* (Fig. 50)
110. Hilar area not black; seed coat not orange; punctulate, favulariate, striate, greasy in appearance111
111. Twisted, transversely ridged, beveled, trapezoidal; gray-yellow, olive green; length 0.9-1.4 mm., width 0.5-0.7 mm.; cotyledons obliquely incumbent5a. *Sisymbrium officinale* (Fig. 3)
111. Flat, occasionally slightly transversely ridged; yellow; length 0.8-1.1 mm., width 0.5 mm.; cotyledons incumbent2. *Sisymbrium altissimum* (Fig. 4)
112. A polyhedron varying from 5 to 8 sides, each plane outlined in a dark brown edge; wings present, varying, not present on all edges; orange; length 0.6-0.9 mm., width 0.4-0.5 mm.42. *Arabis glabra* (Fig. 26)
112. Slightly compressed laterally, narrowly obovoid or flatter and folded, one claw lying in part upon another; orange or gray; length 1.0-1.2 mm., width 0.7-0.8 mm.; cotyledons conduplicate113
113. Mucilaginous envelope develops when placed in water; beak curving toward cotyledonary base79. *Diplotaxis muralis* (Fig. 29)
113. No mucilaginous envelope develops when placed in water; beak straight80. *Diplotaxis tenuifolia*

II. Key to Fruits and Seeds from Indehiscent Fruits¹

1. Fruits globose or broader than long 2
1. Fruits longer than broad 4
2. Fruit globose to turbinate; fruit coat alveolate, granules superimposed; fruit length 1.9-2.2 mm., width 2.0-2.4 mm.—Seed ovoid with a conspicuous radicular ridge; punctulate112. *Neslia paniculata* (Fig. 84)
2. Fruit much broader than long.—Seed coat reticulate-areolate, lineolate, in part 3

¹ Fruit characters are given first, seed characters second, and spaced.

3. Fruit length 1.5 mm., width 2.0 mm.; valve conspicuous and indented; fruit coat rugose.—Seed auriculate in shape102. *Coronopus didymus* (Fig. 86)
3. Fruit length 2.5 mm., width 3.1 mm.; valve inconspicuous; fruit coat strongly rugose.—Seed oblong-obovate, eccentric103. *Coronopus procumbens* (Fig. 88)
4. Jointed or slightly constricted 5
4. Not jointed 9
5. Two-jointed 6
5. More than 2 joints or pseudo joints being merely constricted.—Radicular ridge and two adjoining ridges prominent; alveolate 7
6. Smooth; length 2 cm. or less; upper joint larger, conical, lower joint obovoid, joints 1-seeded.—Seed tan; punctulate; length 4.3-5.7 mm., width 1.7-2.8 mm.89a. *Cakile edentula* var. *lacustris* (Fig. 91)
6. Ridged, sulcate; length 5.0 mm. or less.—Seed oblong; length 1.5-1.8 mm., width 0.9-1.2 mm.88. *Rapistrum rugosum* (Fig. 93)
7. Fruit width over 2 mm. 8
7. Fruit width under 2 mm., length 3 cm.; beak one-third of length.—Seed length 1.4-1.6 mm., width 0.7-1.0 mm.; greenish-yellow; punctulate and lineolate61. *Chorispora tenella* (Fig. 89)
8. Joints 4-8, longitudinally grooved.—Seed oblong, occasionally sub-globose; length 2.1-2.5 mm., width 1.5-1.9 mm.; interstices elongate; seed pointed at base90. *Raphanus raphanistrum* (Fig. 87)
8. Joints 3-4, not longitudinally grooved.—Seed sub-globose, slightly flattened variously; length 3.0-3.5 mm., width 3.0-3.4 mm.91. *Raphanus sativus* (Fig. 85)
9. Length 4 cm. or more; broadly oval to elliptic, papery, reticulate-veined 10
9. Length 2.5 cm. or less 11
10. Broadly oval.—Seed with three or four dark lines meeting near hilar area; length 8.0-8.5 mm., width 6.8-7.0 mm.; wing width 1.0-1.3 mm.; reticulate, very low reticulum, obscured by rugae on seed proper63. *Lunaria annua* (Fig. 94)
10. Elliptic, pointed at both ends.—Seed with two double-banded dark streaks meeting at the hilar area; length 9.5-10.0 mm., width 7.6-8.0 mm., wing width 1.0-1.2 mm.; interspaces of reticulum elongate on wing, not on seed proper64. *Lunaria rediviva*
11. Fruits turbinate, a little longer than broad; 3-celled; 1-seeded.—Seed oblong or broadly oval; radicular side considerably longer than cotyledonary side; length 2.0-2.2 mm., width 1.0-1.1 mm.53. *Myagrum perfoliatum* (Fig. 92)
11. Fruit cuneate, samara-like.—Seed columnar-terete; radicular ridge prominent; frequently pubescent at base; length 2.7-3.0 mm., width 0.9-1.0 mm.54. *Isatis tinctoria* (Fig. 90)

TAXONOMIC DESCRIPTIONS

The genera are arranged according to Hayek's (1911) system of classification whereas the species of each genus appear in alphabetical sequence. A conspectus of Hayek's system as represented by genera found in northeastern North America, follows for the convenience of the reader. The general distribution of the species is based on data given in monographs and standard manuals.

Sequence and Numbers of Genera According to Hayek's Classification

I. THELYPODIEAE

1. *Stanleya pinnata*

II. ARABIDAE

Sisymbriinae

2. *Sisymbrium altissimum*
3. *Sisymbrium Irio*
4. *Sisymbrium loeselii*
5. *Sisymbrium officinale*
- 5a. *Sisymbrium officinale*
var. *leiocarpum*
6. *Descurainia pinnata*
7. *Descurainia Richardsonii*
8. *Descurainia Sophia*

Erysiminae

9. *Erysimum asperum*
10. *Erysimum cheiranthoides*
11. *Erysimum inconspicuum*
12. *Erysimum repandum*

Cardamininae

13. *Armoracia aquatica*
14. *Barbarea verna*
15. *Barbarea vulgaris*
16. *Rorippa austriaca*
17. *Rorippa curvisiliqua*
18. *Rorippa islandica*
19. *Rorippa obtusa*
20. *Rorippa sessiliflora*
21. *Rorippa sinuata*
22. *Rorippa sylvestris*
23. *Nasturtium officinale*
24. *Cardamine bellidifolia*
25. *Cardamine bulbosa*
26. *Cardamine Clematitidis*
27. *Cardamine Douglassii*
28. *Cardamine hirsuta*
29. *Cardamine parviflora*
var. *arenicola*
30. *Cardamine pennsylvanica*
31. *Cardamine pratensis*
- 31a. *Cardamine pratensis*
var. *palustris*
32. *Cardamine rotundifolia*
33. *Dentaria laciniata*

34. *Leavenworthia torulosa*

35. *Leavenworthia uniflora*

36. *Arabidopsis Thaliana*

Arabidinae

37. *Arabis alpina*
38. *Arabis arenicola*
39. *Arabis canadensis*
40. *Arabis divaricarpa*
41. *Arabis Drummondii*
42. *Arabis glabra*
43. *Arabis hirsuta*
var. *pyncocarpa*
44. *Arabis Holboellii*
45. *Arabis laevigata*
46. *Arabis lyrata*
47. *Arabis missouriensis*
48. *Arabis patens*
49. *Arabis perstellata*
var. *Shortii*
50. *Alliaria officinalis*
51. *Halimolobos mollis*¹
52. *Sibara virginica*

Isatidinae

53. *Myagrum perfoliatum*
54. *Isatis tinctoria*

III. ALLYSSEAE

Hesperidinae

55. *Cheiranthus Cheiri*
56. *Iodanthus pinnatifidus*
57. *Hesperis matronalis*
58. *Matthiola incana*

Brayinae

59. *Braya humilis*
60. *Braya Longii*
61. *Chorispora tenella*

Lunariinae

62. *Selenia aurea*
63. *Lunaria annua*
64. *Lunaria rediviva*

Alyssinae

65. *Berteroa incana*
66. *Berteroa mutabilis*

¹ See Rollins (1943) article on the problem of generic lines among the close relatives of *Halimolobos*.

67. *Alyssum alyssoides*
68. *Lobularia maritima*

Drabinae

69. *Draba arabisans*
70. *Draba brachycarpa*
71. *Draba cuneifolia*
72. *Draba fladriensis*
73. *Draba glabella*
74. *Draba lanceolata*
75. *Draba nemorosa*
76. *Draba ramosissima*
77. *Draba reptans*
78. *Draba verna*

IV. BRASSICAEAE

Brassicinae

79. *Diplotaxis muralis*
80. *Diplotaxis tenuifolia*
81. *Brassica campestris*
81a. *Brassica campestris* var. *rapa*
82. *Brassica hirta*
83. *Brassica juncea*
84. *Brassica kaber*
85. *Brassica nigra*
86. *Eruca sativa*
87. *Erucastrum gallicum*

Raphaninae

88. *Rapistrum rugosum*
89. *Cakile edentula*
89a. *Cakile edentula*
var. *lacustris*
90. *Raphanus raphanistrum*
91. *Raphanus sativus*

Moricandiinae

92. *Conringia orientalis*

V. LEPIDIEAE

Lepidiinae

93. *Lepidium campestre*
94. *Lepidium densiflorum*
95. *Lepidium latifolium*
96. *Lepidium perfoliatum*
97. *Lepidium ruderalis*
98. *Lepidium sativum*
99. *Lepidium virginicum*
100. *Cardaria Draba*
101. *Cardaria pubescens*
102. *Coronopus d. dymus*
103. *Coronopus procumbens*

Iberidinae

104. *Hutchinsia procumbens*
105. *Iberis amara*

Thlaspidinae

106. *Cochlearia officinalis*
107. *Thlaspi arvense*
108. *Thlaspi perfoliatum*

Capsellinae

109. *Camelina microcarpa*
110. *Camelina Parodii*
111. *Camelina sativa*
111a. *Camelina sativa*
var. *dentata*
112. *Neslia paniculata*
113. *Capsella bursa-pastoris*
114. *Capsella rubella*

Subulariinae

115. *Subularia aquatica*

VI. SCHIZOPETALEAE

Physariinae

116. *Lesquerella globosa*
117. *Lesquerella gracilis*
118. *Lesquerella ludoviciana*

1. STANLEYA PINNATA (Pursh) Britt. Trans. N. Y. Acad. Sci. 8: 62. 1888

Fig. 80

Length (2.0)-2.2-(2.3) mm., width (0.9)-1.0-(1.0) mm.; shape oblong; color greenish brown; seed coat areolate-scalariform, rough in part, greasy in appearance; a prominent cleft; both emarginate and winged at apex; cotyledons incumbent.

Distribution: South Dakota, Nebraska, eastern Colorado, Arizona and New Mexico.

Material studied: N. Mex. (F); Nebr. (US); Colo. (US).

Seed illustrated: Gallup, N. Mex., June 22, 1927, F 722240, David Goddard.

2. SISYMBRIUM ALTISSIMUM L. Sp. Pl. 659. 1753

Fig. 4

Length (0.8)-0.9-(1.1) mm., width 0.5 mm.; shape short oblong, usually flat, sometimes slightly transversely ridged; color cream to yellow; seed coat punctulate, favulariate or striate; greasy in appearance; outer side, primary groove prominent; inner side, primary and secondary grooves evident; radicular ridge frequently very prominent; cotyledons incumbent.

Distribution: Widely distributed across northern United States and southern Canada. Introduced from Europe.

Material studied: Ill. (F); Minn. (P); Wash. D. C. (FSL); Mont. (US); Tex. (US); Nev. (FPI); Ia. (ISCSL).

Seed illustrated: A. Railroad tracks, Evanston, Ill., Sept. 13, 1947. M. Murley. B. Ill., Oct. 11, 1901, F 103598, O. E. Lansing.

Remarks: Mass collections, railroad track, Evanston, Ill., Sept. 13, 1947, and Sept. 9, 1948, M. Murley.

3. *SISYMBRIUM IRIO* L. Sp. Pl. 659. 1753

Length (0.8)-0.9-(0.9) mm., width (0.4)-0.5-(0.5) mm.; shape oval-oblong; color pure yellow, hilar area outlined in red; seed coat smooth, vernicose; primary groove in distinct; cotyledons incumbent.

Distribution: Locally weedy in the east states, Texas, Arizona. Introduced from Europe.

Material studied: N. Jer. (US); Tex. (2 stations) (US, FPI); Ariz. (US).

4. *SISYMBRIUM LOESELII* L. Cent. Pl. 1: 18. 1775

Fig. 5

Length (0.8)-0.9-(0.9) mm., width (0.4)-0.5-(0.5) mm.; shape oval-oblong; color bright orange, hilar area red; seed coat punctulate, undulate; smooth in part; primary groove not as prominent as in *S. altissimum* and *S. officinale*; hilar area elongate; cotyledons incumbent.

Distribution: Reported from Connecticut, Massachusetts, Illinois, North Dakota, South Dakota, Nebraska, Idaho. Adventive from Europe.

Material studied: N. Dak. (2 stations) (F); S. Dak. (US); Mass. (2 stations) (F); Czech. (BUT).

Seed illustrated: Devil's Lake, N. D., July 15, 1920, F 689242; O. A. Stevens.

5. *SISYMBRIUM OFFICINALE* (L.) Scop. Fl. Carn. ed. 2, 2: 26. 1772

No differentiating seed characters could be found to distinguish the species from the variety.

Distribution: Local in northeastern United States and Canada. Naturalized from Europe.

Material studied: Ill. Murley; Ia. (ISC).

5a. *SISYMBRIUM OFFICINALE* (L.) Scop. var. *LEIOCARPUM* DC. Prodr. 1: 191. 1824

Fig. 3

Length (0.9)-1.2-(1.4) mm., width (0.5)-0.5-(0.7) mm.; shape highly variable being transversely ridged, beveled, flat, ovoid-twisted, linear trapezoidal (see chapter on mass collections); color yellow, gray-yellow, olive green, gray; seed coat punctulate, favulariate or striate, greasy in appearance; radical ridge may or may not be prominent; high transverse ridge frequent; cotyledons obliquely incumbent.

Distribution: Widely distributed throughout North America. Much more common than the species. Naturalized from Europe.

Material studied: Mo. (US); Ind. (Kb); Ill. (2 stations) (F); Ia. (ISCSL); Mont. (US); Calif. (US).

Seeds illustrated: Sherman Ave., vacant lot, Evanston, Ill., Sept. 6, 1948, M. Murley. A. Plant 25, B. Plant 22, C. Plant 25, D. Plant 24, E. Plant 24, F. Plant 23, G. Plant 23.

Remarks: Mass collections of 20 plants, Lake Michigan shore, Northwestern Campus, Evanston, Ill., Sept. 4, 1947; of 25 plants, Sherman Ave., Evanston, Ill., Sept. 6, 1948, M. Murley.

6. *DESCURAINIA PINNATA* (Walt.) Britt. var. *BRACHYCARPA* (Richards.) Fern.

Gray's Man. Bot. ed. 8, 711. 1950

Fig. 7

Descurainia brachycarpa (Richards.) O. E. Schulz. *Sisymbrium canescens* var. *brachycarpum* (Richards.) Wats.

Length (0.9)-1.0-(1.1) mm., width (0.4)-0.4-(0.5) mm.; shape ellipsoid to narrowly oval; color brownish red; seed coat reticulate-foveate, the pit-like interspaces small; wide depression on the inner side running the length of the seed; cotyledons incumbent.

Distribution: Eastern slopes of the Rocky Mountains, Great Plains, Ohio Valley, New England States and Quebec; also north in the Great Slave Lake region.*Material studied:* Ill. (SPR); Ia. (ISC); Mont. (US); Que. (US); Minn. (US); Ind. (Kb); Mo. (F).*Seed illustrated:* Union Co., Ill., May 19, 1940, F 1073905, Bill Bauer.7. *DESCURAINIA RICHARDSONII* (Sweet) O. E. Schulz

Pflanzenreich, 4, Fam. 105: 318. 1924

Length (1.0)-1.1-(1.1) mm., width (0.5)-0.6-(0.7) mm., shape: (a) Truncate at base somewhat squarish, and (b) not truncate at base oblong-ellipsoid; color dark reddish-brown; seed coat reticulate-areolate, alveolate or scalariform in part; cotyledons incumbent.

Distribution: Great Slave Lake region to the Great Lakes region and North Dakota, on the slopes of the Rocky Mountains as far south as northern Colorado.*Material studied:* Alberta, Detling; Wyo., Detling; Colo. (FPI); Oregon (F).8. *DESCURAINIA SOPHIA* (L.) Webb. Prantl, in Engler & Prantl,

Nat. Pfl. Fam. 3, Abt. 2: 192. 1892

Fig. 6

Sophia sophia (L.) Britt. *Sisymbrium Sophia* L.

Length (0.8)-0.9-(0.9) mm., width 0.4 mm.; shape oblong-ellipsoid or narrowly oval; color bright orange; seed coat scalariform; both primary and secondary grooves prominent; cotyledons incumbent.

Distribution: Well established throughout the United States, Canada and Alaska. Naturalized from Europe.*Material studied:* Tex. (US); Nev. (FPI); Calif. (US); Ia. (US); (ISC); Ill. (F); Mich. (US); Quebec (US).*Seed illustrated:* Quebec, 1909, US 8725311, F. Marie-Victorin.9. *ERYSIMUM ASPERUM* (Nutt.) DC. Syst. 2: 505. 1821

Fig. 65

Cheirinia aspera (DC.) Britt.

Length (1.7)-1.9-(2.0) mm., width (0.7)-0.8-(0.8) mm.; shape narrowly elongate-oval or ellipsoid; color dark orange to red, very black thick base on cotyledonary side; seed coat granulate, alveolate in part in early stages of differentiation; wing present at apex, granulate, highly variable in length; cotyledons incumbent.

Distribution: In north central and eastern United States and Canada.*Material studied:* Wash. (ISC); Calif. (P); Va. (P); S.D. (ISC); Mo. (FSL); Wash. D.C. (FSL).*Seed illustrated:* Allenton, Mo., Letterman.10. *ERYSIMUM CHEIRANTHOIDES* L. Sp. Pl. 661. 1753

Fig. 50

Cheirinia cheiranthoides (L.) Link.

Length (1.0)-1.1-(1.4) mm., width (0.3)-0.4-(0.5) mm.; shape highly variable; conical, flat, twisted-conical, trapezoidal, ovoid; color orange, darker in the hilar area;

seed coat reticulate-areolate to minutely tuberculate; a wing frequently present at apex; cotyledons obliquely incumbent and incumbent.

Distribution: Widely distributed across northern United States and southern Canada. Native to both North America and Europe.

Material studied: Md. (FSL); Wisc. (ISC); Me. (ISC); N.Y. (ISC); Ill. (2 stations) (F); Mass. (F); S.D. (F); Minn. (ISC); Ia. (2 stations) (ISC).

Seed illustrated: A. Skokie Lagoons, Glencoe, Ill., July 11, 1948, Plant No. 2. M. Murley. B. Lime Springs, Ia., Sept. 2, 1918, ISC, L. H. Pammel.

Remarks: Mass collections, (a) colony of 25 plants, seeds collected from base and apex, July 11, 15, 1948, Skokie Lagoons, Glencoe, Ill.; (b) colony of 25 depauperate plants, seeds collected from base and apex, July 11, 15, 1948, *ibid.*; (c) colony of 25 second growth plants, Aug. 5, 1948, Waukegan State Park, Ill.

11. ERYSIMUM INCONSPICUUM (S. Wats.) MacM. Met. Minn. 268. 1892

Fig. 63

Cheirinia inconspicua (S. Wats.) Britt.

Length (1.4)-1.8-(2.0) mm., width (0.7)-0.8-(0.9) mm.; shape ovoid, frequently eccentric at apex and radicular side; color orange; seed coat reticulate-areolate, faveolate in part; wing present at apex, frequently eccentric; inner side with a depression, sometimes a slight transverse ridge, both primary and secondary grooves prominent; cotyledons incumbent.

Distribution: Ontario, Manitoba, British Columbia and in the Great Plains region.

Material studied: Nev. (US); Montana (US); Nebr. (US).

Seed illustrated: Montana, US 5552, F. W. Anderson.

12. ERYSIMUM REPANDUM L. Amolin. Acad. 3: 415. 1726

Fig. 62

Cheirinia repanda (L.) Link.

Length (1.1)-1.3-(1.4) mm., width (0.6)-0.6-(0.7) mm.; shape oblong, flattened uniformly; color yellow orange; seed coat minutely granulate, grains of cuticle in grooves; primary groove deep and dark colored one-fourth its length, not so pronounced apically; emarginate, conspicuously so at apex; cotyledons incumbent.

Distribution: Northeastern and north central states. Introduced from Europe.

Material studied: Ill. (ISM); Ariz. (US); Mo. (US); Ohio (FSL); Neb. (FSL); Ind. (Kb).

Seed illustrated: Long Pine, Nebraska, FSL, J. M. Bates.

13. ARMORACIA AQUATICA (Eat.) Wieg. Rhodora 27: 186. 1925

Fig. 9

Neobeckia aquatica (Eat.) Greene. *Radicula aquatica* (Eat.) B. L. Robins. *Rorippa aquatica* (Eat.) Palmer & Steyererm. *Nasturtium lacustre* A. Gray.

Length (0.5)-0.5-(0.7) mm., width (0.4)-0.5-(0.5) mm.; shape sub-orbicular with claws; color orange, darker at base; seed coat minutely tuberculate, reticulum superfluous and sloughing off; claws somewhat pointed, forming cleft with crest; cotyledons accumbent.

Distribution: Northeastern United States and Canada, also southern United States.

Material studied: Ill. (2 stations) (F); Ala. (US).

Seed illustrated: Ill., July 1874, F 209329, Harry N. Paterson.

14. BARBAREA VERNA (Mill.) Aschers. Fl. Prov. Branderb. 1: 36. 1864

Fig. 53

Barbarea praecox (J. E. Sm.) R.Br.

Length (1.4)-1.9-(2.1) mm., width (0.9)-1.2-(1.4) mm.; shape oblong to orbicular,

pulvinate-depressed; color metallic or gray-brown; seed coat reticulate-foveate, pits both circular and elongate in outline, reticulum coarser and pits deeper than in *B. vulgaris*, cuticle not as abundant, few crystals in the pits; cotyledons accumbent.

Distribution: Massachusetts south to Florida, west to Minnesota, Iowa. Naturalized from Europe.

Material studied: N. C. (US); Va. (ISC), (F); Conn. (ILL.).

Seed illustrated: Dinwiddie Co., Va., May 18, 1939, F 1075872, M. Fernald and B. Long.

15. *BARBAREA VULGARIS* R. Br. Ait. Hort. Kew. ed. 2, 4: 109. 1812

Fig. 54

Barbarea barbarea (L.) MacM. (*Barbarea stricta* of some authors)

Length (1.0)-1.3-(1.4) mm., width (0.9)-1.1-(1.2) mm.; shape orbicular, pulvinate-depressed; color metallic or gray-brown; seed coat reticulate-foveate, pits circular in outline each pit containing an oxylate crystal, cuticle abundant; cotyledons accumbent.

Distribution: Labrador to Virginia, Great Plains and on the Pacific Coast. Naturalized from Europe.

Material studied: Iowa (ISC); Mo. (US); N. Y. (US); Penn. (US); Wash. D. C. (US) Ill. M. Murley; Ind. M. Murley.

Seed illustrated: Lafayette, Ind., Aug. 9, 1947, M. Murley.

Remarks: Mass collection, colony of 15 plants, Evanston, Ill., July 25, 1949. Seed samples from base and apex of fruiting stalk; M. Murley. (See chapter on mass collections.)

16. *RORIPPA AUSTRIACA* Spach Hist. Veg. Phen. 6: 513. 1838

Fig. 23

Radicula austriaca (Crantz) Small.

Length (0.7)-0.8-(0.8) mm., width (0.6)-0.7-(0.7) mm.; shape sub-orbicular; color reddish-brown; seed coat reticulate; depressed on inner side with several faces; claws short and one of them pointed, of nearly equal length, may or may not be in the same plane; cotyledons accumbent.

Distribution: New York, New Jersey, Minnesota, Wisconsin, California and Saskatchewan. Introduced from Europe.

Material studied: Calif. (CSL); Nebr. (US); Europe (US); Minn. (MSL).

Seed illustrated: Corporation Range, Modoc Co., Calif., CSL, M. Bellue.

17. *RORIPPA CURVISILIQUA* (Hook.) Bessey. Mem. Torr. Bot. Club 5: 169. 1894

Radicula curvisiliqua (Hook.) Green.

Length (0.5)-0.6-(0.6) mm., width 0.5 mm.; shape cordiform; color white; seed coat colliculate, lustrous; cotyledons accumbent.

Distribution: Western United States to Nebraska.

Material studied: Wash. (F); Wyo. (US); Nebr. (US).

18. *RORIPPA ISLANDICA* Oeder ex Murray var. FERNALDIANA Butters & Abbe.

Rhodora 42: 28. 1940

Fig. 20

Radicula palustris (L.) Moench.

Length (0.5)-0.6-(0.8) mm., width 0.5 mm.; shape cordiform; color yellow, darker around the notch; seed coat colliculate, lustrous; deep depression running from the notch apically; claws rounded and blunt, may or may not be in the same plane; cotyledons accumbent.

Distribution: Widely distributed in the eastern and north central states and native. Also native in Europe.

Material studied: Ia. (2 stations) (ISC); Ill. (2 stations) (SPR), (F); Ind. (Kb.); Ia. (US); Ohio (US); Mo. (US); Va. (US).

Seed illustrated: Wilmette, Illinois, Aug. 7, 1948, Plant No. 5, M. Murley.

Remarks: Mass collection, colony of 25 plants, Wilmette, Illinois, Aug. 7, 1948.

19. *RORIPPA OBTUSA* (Nutt.) Britt. Mem. Torr. Bot. Club 5: 169. 1894

Radicula obtusa (Nutt.) Greene.

Length (0.5)-0.5-(0.6) mm., width (0.45)-0.5-(0.5) mm.; shape cordiform; color yellow; seed coat reticulate-faveolate; cuticle conspicuous and often filling pits, cuticle or mucilage piled up in some of the pits giving a punctulate appearance on parts of the seed coat; cotyledons accumbent. Upon superficial examination may be confused with *R. sessiliflora*, the cuticle and mucilage being somewhat deceiving.

Distribution: In wet ground, Mississippi valley, Texas, and westward in Montana, California.

Material studied: Quebec (F); Ind. (Kb.); Texas (2 stations) (F), (US); Wash. (ISC); Mo. (ILL); Calif. (F).

20. *RORIPPA SESSILIFLORA* (Nutt.) Hitchc. Spring Fl. Manhattan 18. 1894

Fig. 24

Radicula sessiliflora (Nutt.) Greene.

Length (0.4)-0.45-(0.4) mm., width 0.4 mm.; shape cordiform somewhat apiculate; color light tan; seed coat faveolate, little or no cuticle; depression extending from notch apically; hilum usually conspicuous and elongated; broad rounded claws diverging; cotyledons accumbent.

Distribution: In wet ground from Virginia and in the Mississippi valley; also in Florida and Texas.

Material studied: Mo. (US); Miss. (US); Ind. (3 stations) (US), (Kb), (Kb); Ill. (SPR); Ark. (P); Iowa (ISC).

Seed illustrated: East St. Louis, Illinois, June 4, 1947, ISM 12879, G. Fuller.

21. *RORIPPA SINUATA* (Nutt.) Hitchc. Spring Fl. Manhattan 18. 1894

Radicula sinuata (Nutt.) Greene.

Length (0.7)-0.8-(0.8) mm., width (0.5)-0.6-(0.6) mm.; shape angular, several slant faces and concavities; color pale yellow, sub-lustrous; seed coat ocellate, colliculate, reticulate; cotyledons accumbent.

Distribution: Mississippi valley, Texas, Arizona, California, British Columbia, Wyoming.

Material studied: Nebr. (F); Ia. (ISC); Mo. (F).

22. *RORIPPA SYLVESTRIS* (L.) Besser Enum. 27. 1821

Fig. 21

Radicula sylvestris (L.) Druce.

Length (0.6)-0.7-(0.7) mm., width 0.5 mm.; shape oblong to oblong-oval; color reddish brown; seed coat areolate; one claw longer than the other; primary groove; obscure; cotyledons accumbent.

Distribution: From eastern Canada to Virginia and in the Mississippi valley. Introduced from Europe.

Material studied: N. Jer. (F).

Seed illustrated: New Jersey, June 22, 1871, F 25326, Parker.

23. *NASTURTIIUM OFFICINALE* R. Br. Ait. Hort. Kew. ed. 2, 4: 110. 1812

Fig. 8

Radicula nasturtium-aquaticum (L.) Britten & Rendle.

Length (0.9)-1.0-(1.1) mm., width (0.8)-0.9-(0.9) mm.; shape orbicular, with slightly convex sides; color orange-red, blackened area near the hilar region; seed coat reticulate, reticulum high, sharp, and geometrical being 4-, 5-, and 6-sided; interspaces

around the periphery filled with mucilage and cuticle frequently giving a rim-like or wing-like aspect to the seed; two small pointed claws; cotyledons accumbent.

Distribution: In brooks and streams of northeastern United States and Canada to Missouri, also in California. Introduced from Europe.

Material studied: Tenn. (FPI); Nev. (FPI); Ind. (Kb.), (F); Calif. (F); Utah (F); Ill. (F); Va. (US); Wyo. (ISC); Iowa (ISC).

Seed illustrated: Bedford, Indiana, June 13, 1935, Kb 3189, Ralph Kriebel.

24. *CARDAMINE BELLIDIFOLIA* L. Sp. Pl. 654. 1753

Length (1.4)-1.5-(1.7) mm., width (0.9)-1.0-(1.2) mm.; shape broadly oval, truncate at base, frequently eccentric on cotyledonary side at apex, seeds more uniform in shape than *C. bulbosa*; color orange, reddish orange hilum; seed coat rugose; primary groove distinct but not deep; cotyledons accumbent.

Distribution: White Mountains of New Hampshire, Greenland, the Canadian Rocky Mountains, and in the high montane of Washington and California. Also native in Europe.

Material studied: Wash. (US); Greenland (US); Labrador (US); N. Hamp. (US).

25. *CARDAMINE BULBOSA* (Schreb.) BSP. Prel. Cat. Pl. N.Y. 4. 1888

Fig. 73

Length (1.7)-2.0-(2.1) mm., width (0.8)-1.2-(1.5) mm.; shape highly variable being sub-rectangular with one corner lacking, sub-orbicular, oval and eccentric, elongate-oval or beveled at base; color green-yellow, light orange or dark orange; seed coat ruminate, rugose, favulariate, sulcate; frequently emarginate on some of the edges; radicular ridges more prominent than in *Dentaria laciniata*; usually not as thick as *D. laciniata*; cotyledons accumbent. Certain seeds are difficult to differentiate from *D. laciniata*.

Distribution: Quebec to Minnesota, New England south to Florida, prairies and Great Plains.

Material studied: Mo. (F), (ISC); Texas (US); Ohio (US); Ind. (Kb.); Ill. Murley.

Seeds illustrated: Evanston, Ill., June 7, 1948, A. Plant 16, B. Plant 17, C. Plant 18, D. Plant 19, E. Plant 20. (All from fruits at base of raceme.)

Remarks: Mass collections, two colonies of 20 plants each; seeds collected from base and apex of raceme, June 7, 10, 1948, Harms Forest Preserve, Evanston, Ill., M. Murley.

26. *CARDAMINE CLEMATITIS* Shuttlw. S. Wats. Bibl. Index 1: 53. 1878

Length (1.9)-1.9-(2.1) mm., width (0.7)-1.0-(1.0) mm.; shape elongate oval; color dark brown; seed coat with very fine longitudinal ribs, somewhat irregular and anastomosing on parts of the seed coat; cotyledons accumbent.

Distribution: Virginia to Alabama.

Material studied: N.C. (US); Tenn. (BUT).

27. *CARDAMINE DOUGLASSII* (Torr.) Britt. Trans. N.Y. Acad. Sci. 9: 8. 1888

Cardamine bulbosa var. *purpurea* (Torr.) BSP.

No reliable differentiating characters could be found to differentiate this species from *C. bulbosa*.

Distribution: Quebec to the Rocky Mountains, New England States, prairies and Great Plains.

Material studied: Ill. (US); Ky. (US); W. Va. (US).

Remarks: Mass collection, a colony of 20 plants; seeds collected from base and apex of raceme, June 7, 10, 1948, Harm's Forest Preserve, Evanston, Ill., M. Murley.

28. *CARDAMINE HIRSUTA* L. Sp. Pl. 655. 1753

Fig. 12

Length (1.0)-1.1-(1.1) mm., width (0.7)-0.8-(0.8) mm.; shape broadly oval, oblong or squarish; color orange; seed coat distinctly alveolate when completely differentiated; frequently emarginate or with a narrow wing on some of the edges; cotyledons accumbent.

Distribution: Northeastern United States to Michigan and Nebraska. Probably naturalized from Europe.

Material studied: N. C. (US); Va. (US); Penn. (US); Wash. D. C. (FSL).

Seed illustrated: Weatherby, Va., 1932, US 1567535.

29. *CARDAMINE PARVIFLORA* L. var. *ARENICOLA* (Britt.) O. E. Schulz

Bot. Jahrb. 32: 485. 1903

Fig. 11

Cardamine arenicola Britt.

Length (0.7)-0.8-(0.9) mm., width (0.4)-0.5-(0.6) mm.; shape oblong, frequently with considerable thickness with the lateral sides appearing as plane faces; color bright orange, lustrous; seed coat reticulate-areolate arranged in rows on parts of the seed; beak curving around base of seed; cotyledons accumbent.

Distribution: New England to Florida, Kentucky, Illinois, Iowa, Missouri.

Material studied: Ia. (ISC); Ind. (Kb.); Ark. (US); Mo. (US); Va. (US); Tex. (US); Tenn. (US); Ill. (SPR).

Seed illustrated: Ill., June 3, 1945, ISM 10472, George Fuller.

30. *CARDAMINE PENNSYLVANICA* Muhl. Willd. Sp. Pl. 3: 486. 1800

Fig. 14

Length (0.7)-0.7-(0.8) mm., width (0.5)-0.5-(0.6) mm.; shape broadly oval, short oval or oblong, cotyledonary side frequently thicker than the radicular side of seed; color light reddish tan, glassy in appearance, almost transparent, lined and sometimes mottled in red; seed coat glebulate with a lineate background; conspicuously emarginate; funicular material prominent forming two projections beyond the seed proper; hilum broad and darkened.

Distribution: In wet ground, widely distributed throughout the United States and southern Canada.

Material studied: Ia. (ISC); Ill. (SPR); Mont. (US); N.D. (US); Pr. Ed. Is. (US); Quebec (US).

Seed illustrated: Ames, Iowa, 1907, ISC, A. Hayden.

Remarks: Mass collections, two colonies of 20 plants each; seeds collected from base and apex of raceme, June 10, 1948, Harms Forest Preserve, Evanston, Ill.

31. *CARDAMINE PRATENSIS* L. Sp. Pl. 2: 653. 1753

Mature seeds of this species were not available.

Distribution: Eurasia, Alaska, and as an introduced plant in lawns and meadows from Newfoundland to New England.

31a. *CARDAMINE PRATENSIS* L. var. *PALUSTRIS* Wimm. & Crab. Fl. Siles 2: 266. 1829

Fig. 13

Length (1.1)-1.1-(1.2) mm., width (0.5)-0.6-(0.7) mm.; shape oblong; color orange; seed coat reticulate areolate; primary groove deep; radicular side longer and beak curving toward the cotyledonary side of seed; emarginate in part; cotyledons accumbent.

Distribution: Ungava to Mackenzie, Newfoundland, Quebec, New England States to Ohio, northern Indiana, Minnesota and British Columbia. Indigenous to both North America and Eurasia.

Material studied: Mich. (F); Oregon (ISC), (F); Ind. (BUT).

Seed illustrated: Flint, Mich., F 4212, D. Clark.

32. *CARDAMINE ROTUNDIFOLIA* Michx. Fl. Bor. Am. 2: 30. 1803

Length (0.8)-0.8-(1.0) mm., width (0.7)-0.7-(0.8) mm.; shape sub-orbicular; color dark orange; seed coat glebulate and lineolate; cotyledons accumbent. Difficult to distinguish from *C. pennsylvanica*.

Distribution: New York to Ohio, south to North Carolina and Kentucky.

Material studied: Ohio (US); W. Va. (US); Penn. (BUT).

33. *DENTARIA LACINIATA* Muhl. Willd. Sp. Pl. 3: 479. 1800

Fig. 75

Length (1.9)-2.4-(2.7) mm., width (1.9)-1.8-(2.2) mm., thickness (0.8)-1.0-(1.0) mm.; shape variable frequently squarish or ovoid; color green, greenish orange or dark orange; seed coat ruminate, rugose or favulariate; seed frequently appearing layered or laminated with considerable thickness; cotyledons accumbent and transversely bent near their base and not at the cotyledonary node, cotyledons frequently longer than the radicular ridge and rolling in. The peculiarity of the cotyledon relates to the laminate and thickened condition. This according to Havek (1911) does not justify the separation of *Dentaria* from *Cardamine*. In view of the fact that not all seeds of *D. laciniata* have this laminate thickened condition, and that they are difficult to distinguish from *Cardamine bulbosa*, is one more point in favor of merging the two genera. On the other hand Detling (1936) retained *Dentaria* and *Cardamine* as two separate genera using rhizome and leaf characters, primarily, for differentiating the two genera.

Distribution: Quebec to Florida, west through the prairies and Great Plains.

Material studied: N.C. (F); Va. (P); Ia. (ISC); Ill. (SPR), Murley.

Seed illustrated: Thatcher's Woods, Chicago, Ill., June 9, 1948, M. Murley, A. Plant No. 5, B. Plant No. 11.

Remarks: Mass collections, three colonies of 25 plants each, Thatcher's Woods, Chicago, Ill., June 9, 1948.

34. *LEAVENWORTHIA TORULOSA* A. Gray. Bot. Gaz. 5: 26. 1880

Length (2.4)-2.7-(2.8) mm., width (1.9)-2.0-(2.2) mm.; shape oblong to orbicular, buckled; color of seed proper dark brown, of wing dark brown or dark orange; seed coat and wing reticulate, reticulum low and interspaces shallow; wing and seed coat merging imperceptibly in places, where distinguishable wing is 0.15-0.3 mm. in width; cleft with crest; texture of seed parchment-like; embryo nearly straight, not truly accumbent.

Distribution: Kentucky, Tennessee, northern Alabama.

Material studied: Tenn. (3 station) (F), (US), (US).

35. *LEAVENWORTHIA UNIFLORA* (Michx.) Britt. Mem. Torr. Club 5: 171. 1894

Fig. 83

Length (2.5)-3.0-(3.4) mm., width (2.5)-2.9-(3.0) mm.; shape orbicular to sub-orbicular, buckled; color of seed proper dark brown, of wing orange; seed coat and wing reticulate, reticulum low and interspaces shallow; wing width 0.3-0.5 mm., distinct from seed proper, cleft with crest, which is sometimes areolate; texture of seed parchment-like; embryo only slightly bent, the radicular ridge very short, cotyledons approaching the accumbent condition.

Distribution: Southern Indiana, Tennessee, west to Missouri.

Material studied: Tenn. (2 stations) (F), (US); Ind. (2 stations) (F), (US); Ark. (US); Mo. (US).

Seed illustrated: Rutherford Co., Tenn., April 20, 1940, F 1828430, A. J. Sharp and R. E. Shanks.

36. *ARABIDOPSIS THALIANA* (L.) Heynh. Ill. Fl. NE US R Can. 2: 176. 1913
Fig. 30

Sisymbrium Thalianum (L.) J. Gray. *Arabis Thaliana* L.

Length (0.35)-0.35-(0.4) mm., width 0.2 mm.; shape broadly oblong or broadly oval; color orange streaked with red; seed coat verruculate and areolate, glistening; primary and secondary grooves evident, secondary groove in a central position; hilar area elongate; cotyledons incumbent.

Distribution: Reported from Massachusetts to Georgia and westward to Arkansas, Missouri, Minnesota and Ontario and Utah. Naturalized from Europe.

Materials studied: Ill. (F); Va. (FPI); Ia. (ISC).

Seed illustrated: Alexander Co., Ill., May 11, 1940, F 1073951, Bill Bauer.

37. *ARABIS ALPINA* L. Sp. Pl. 664. 1753

Length (1.1)-1.3-(1.3) mm., width (0.9)-1.0-(1.0) mm.; shape broadly oval to orbicular; color of seed proper red, of wing yellow; seed coat minutely rugose and reticulate-areolate; wing 0.12 mm. in width, absent at extreme base; cleft V-shaped; hilum evident and elongate; cotyledons accumbent. (Similar to *A. virginica*.)

Distribution: Native, reported from Gaspé, Labrador, Quebec, and within the Arctic Circle.

Material studied: Labrador (F); Greenland (F); Quebec (F).

38. *ARABIS ARENICOLA* (Richards.) Gelert. Bot. Tidskr. 21: 270. 1898

Fig. 36

Length (1.2)-1.3-(1.5) mm., width (0.4)-0.5-(0.6) mm.; shape oblong or twisted conically; color orange; seed coat alveolate, glebulate in part; small wing may be present at apex and base; primary groove deep; cotyledons obliquely incumbent.

Distribution: Greenland, Baffin Island, Quebec and Labrador.

Material studied: Greenland (F); Ungava (US); Labrador (US).

Seed illustrated: Greenland, July 19, 1929, F 719212, Porsild and Porsild.

39. *ARABIS CANADENSIS* L. Sp. Pl. 665. 1753

Fig. 56

Length, seed proper (1.3)-1.4-(1.6) mm., with wing (2.6)-3.0-(3.8) mm.; width, seed proper (1.0)-1.1-(1.2) mm., with wing (2.0)-2.4-(3.0) mm.; shape of seed proper oval; color of seed proper deep orange, outlined by a dark line; seed coat reticulate-areolate; wing width 0.7-1.0 mm., inner band orange and reticulate-areolate, outer band light yellow and lineolate; primary groove deep and curving near apex of seed; cotyledons accumbent.

Distribution: Massachusetts to Minnesota, Ontario, south to Georgia and Texas, west to Nebraska and Kansas.

Material studied: Ill. (F); Ia. (ISC); Ind. (Neb); Md. (FSL); Mich. (FSL); Mo. (FSL); Va. (P).

Seed illustrated: Davis Co., Iowa, June 26, 1938, ISC, Ada Hayden.

40. *ARABIS DIVARICARPA* Nels. Bot. Gaz. 30: 193. 1900

Fig. 32

Arabis confinis Wats. *Arabis brachycarpa* (T. & G.) Britt.

Length (1.2)-1.4-(1.6) mm., width (0.8)-0.9-(1.0) mm.; shape oval, ovoid oblong; color orange, areolate pattern and margin of seed in red; seed coat with a large reticulate-areolate pattern; wing usually banded and always present at apex, width 0.15-0.28 mm., wing not always present on the cotyledonary and radicular side and if present narrower

than the wing at the apex; hilar area red, elongated and banded; beak present; cotyledons accumbent.

Distribution: New York to Quebec, Great Lakes region and Great Plains to the Far West.

Material studied: Colo. (ISC); Mich. (US); Minn. (US); Quebec (US); Wyo. (ISC).

Seed illustrated: Custer Co., Colo., June 26, 1936, ISC, Reed Rollins.

41. *ARABIS DRUMMONDI* Gray.¹ Proc. Am. Acad. 6: 187. 1866

Fig. 31

Length (1.1)-1.3-(1.5) mm., width (1.1)-1.4-(1.5) mm.; shape broadly orbicular; color of seed proper dark brown, of wing yellow; seed coat granulate; wing width 0.15-0.2 mm., wider on lateral sides, reticulate-areolate; hilar area banded; cotyledons accumbent.

Distribution: Labrador, Quebec, south to New Jersey, Great Plains and west to California and Washington.

Material studied: Quebec (US); Calif. (P); Colo. (ISC); Minn. (US); Mont. (US); N. Y. (US); Ia. (ISC).

Seed illustrated: Lake Co., Calif., July 10, 1936, ISC, Reed Rollins.

42. *ARABIS GLABRA* (L.) Bernh. Supt. Verz. Erf. 195. 1800

Fig. 26

Length (0.6)-0.8-(0.9) mm., width (0.4)-0.5-(0.5) mm.; shape polyhedral varying from five to eight faces, each face outlined by a dark brown edge; color orange; seed coat areolate; wing usually present but not on all edges; cotyledons accumbent.

Distribution: Quebec, Pennsylvania, North Carolina to the Far West; a circumboreal species. Native also in Europe.

Material studied: Alberta (ISC); Calif. (P); Ill. (F); Ind. (BUT); Wash. (BUT); Ia. (ISCSL).

Seed illustrated: Iowa, 1930, ISCSL.

43. *ARABIS HIRSUTA* (L.) Scop. var. *PYCNOCARPA* (Hopk.) Rollins. Rhodora 43: 318. 1941

Arabis pycnocarpa Hopk.

Length (1.1)-1.1-(1.2) mm., width (0.4)-.06-(0.7) mm.; shape oval to oblong; color dark yellow to brown, darker line around edge of seed proper; seed coat and wing reticulate-areolate; cotyledons accumbent.

Distribution: Quebec to Yukon, south to Georgia, Great Plains to California.

Material studied: Ind. (Kb.); Ia. (ISC); Nev. (ISC); Quebec (ISC).

44. *ARABIS HOLBOELLII* Hornem.² Fl. Dan. 11. t. 1879. 1828

Fig. 33

Length (1.4)-1.6-(1.7) mm., width (1.2)-1.4-(1.5) mm.; shape orbicular; color variegated due to red cotyledonary side, yellow radicular side, inner band of wing red, outer band of wing yellow; seed coat areolate to rugose in part; wing complete, incompletely banded, inner band glebulate, outer band reticulate-areolate; cotyledons accumbent.

Distribution: Greenland, Quebec, Alberta, Yukon, British Columbia and Washington.

Material studied: Calif. (P); Greenland (F); Mich. (US).

Seed illustrated: California, 1937, P.

¹ See Rollins' (1941) monograph in which he does not recognize any varieties of *Arabis Drummondii*.

² See Rollins' (1941) monograph concerning variations of *Arabis Holboellii*.

45. *ARABIS LAEVIGATA* (Muhl.) Poir. Lam. Encycl. Suppl. 1: 411. 1810

Fig. 59

Length with wing (1.3)-1.6-(1.8) mm., seed proper (1.1)-1.4-(1.5); width with wing (0.9)-1.2-(1.3) mm., seed proper (0.8)-1.0-(1.1); shape apiculate oblong; color dull orange; seed coat and wing reticulate-areolate; wing surrounding seed, widest at apex, frequently narrowest on cotyledonary side; cotyledons accumbent.

Distribution: Reported from Quebec to Ontario, South Dakota, Georgia, and Arkansas.

Material studied: Ill. (F); Ind. (Kb.); Ia. (ISC); Va. (P).

Seed illustrated: Harm's Forest Preserve, Evanston, Ill., Aug. 23, 1948, Plant No. 3, M. Murley.

Remarks: Mass collection, colony of 25 plants, see data above.

46. *ARABIS LYRATA* L. Sp. Pl. 665. 1753

Fig. 28

Length (0.7)-0.7-(0.9) mm., width 0.5 mm.; shape oblong or narrowly oval; color orange yellow, darker at cotyledonary base; seed coat reticulate-areolate, scalariform in part; wing may be present at tip, very narrow, areolate; base of cotyledonary side flattened; beak present; primary groove slightly off center; cotyledons accumbent. (Close to *A. dentata*.)

Distribution: New England west to Ontario and Minnesota, south through Georgia, Tennessee and Missouri; also reported from Alberta.

Material studied: Ill. (US); Ia. (ISC); Mass. (ISC); Mich. (US); Wisc. (US).

Seed illustrated: Dunes, Tremont, Ind., July 18, 1948, Jane Roller.

Remarks: Mass collection, see data above.

47. *ARABIS MISSOURIENSIS* Greene. Fedde, Repert. Nov. Sp. V. 244. 1908

Fig. 35

Arabis viridis Harger.

Length (1.6)-1.7-(1.9) mm., width (1.2)-1.2-(1.3) mm.; shape orbicular or oblong, frequently truncate at base; seed coat proper orange, but outlined in red, inner band of wing yellow, outer band of wing white; seed coat ruminant, glebulate in part; wing scaled, inner band glebulate, outer band punctulate; cotyledons accumbent.

Distribution: New England to Georgia, west to Michigan, Missouri, Arkansas and Oklahoma.

Material studied: Ark. (F); Maine (US); Mo. (US).

Seed illustrated: Arkansas, June 12, 1938, F. 1020144, Fassett.

48. *ARABIS PATENS* Sulliv. Am. Jour. Sci. 42: 49. 1842

Length (1.1)-1.4-(1.7) mm., width (0.6)-0.7-(0.9) mm.; shape oblong to oval; color golden yellow; seed coat punctulate to minutely ruminant; wing width less than 0.15 mm., widest at apex, frequently emarginate as well as winged at apex; cotyledons accumbent.

Distribution: Reported from Pennsylvania to Indiana and Tennessee.

Material studied: Ind. (BUT); Ia. (ISC); Nev. (ISC); Quebec (ISC).

49. *ARABIS PERSTELLATA* E. L. Br. var. *SHORTII* Fern. Rhodora 48: 208. 1946

Arabis dentata (Torr.) T. & G.

Length (1.0)-1.1-(1.1) mm., width (0.4)-0.6-(0.7) mm.; shape oblong or narrowly oval; color dark orange with a darker line around the periphery of seed; coat rough;

beak present and curving toward the cotyledonary side; primary groove shallow; cotyledons accumbent. (Similar to *A. lyrata*.)

Distribution: New York to Minnesota and eastern Nebraska and Kansas south to Tennessee and Arkansas.

Material studied: Ill. (F); Ia. (ISC); Mo. (US); W. Va. (US).

Remarks: Mass collection, colony of 10 plants; July 4, 1948; Wheeling, Ill.

50. *ALLIARIA OFFICINALIS* Andr. ex DC. Syst. Veg. 2: 489. 1821

Fig. 55

Alliaria Alliaria Britt.

Length (2.5)-3.0-(3.8) mm., width (1.0)-1.0-(1.1) mm.; shape ellipsoid, inner side beveled or oblique at apex, may be flat, bear a transverse ridge near apex, or a transverse ridge in middle, outer side flat; color black; seed coat with dichotomously branching longitudinal ribs, a few concentrically arranged on the apical inner side; cotyledons incumbent.

Distribution: Introduced from Europe, roadside and waste places in northeastern United States, Quebec and Ontario.

Material studied: Ky. (US); N. Y. (US); Ill., Murley.

Seed illustrated: Roadside, Winnetka, Ill., July 15, 1948, Plant No. 4, apex of raceme, M. Murley.

Remarks: Mass collections from a colony of 25 plants; see data above.

51. *HALIMOLOBUS MOLLIS* (Hook.) Rollins. *Rhodora* 43: 480. 1941

Arabis Hookeri Lange.

Length (1.0)-1.2-(1.2) mm., width (0.4)-0.5-(0.5) mm.; shape ellipsoid to narrowly oblong; color orange; seed coat punctulate to finely irregularly ribbed in part; both primary and secondary grooves deep; wingless; funicular material abundant; cotyledons obliquely incumbent.

Distribution: Western coast of Greenland and the Yukon territory.

Material studied: Greenland (F); Yukon (F).

52. *SIBARA VIRGINICA* (L.) Rollins.¹ *Rhodora* 43: 481. 1941

Fig. 27

Arabis virginica (L.) Poir. *Arabis ludoviciana* Meyer.

Length (1.1)-1.2-(1.5) mm., width (0.8)-1.1-(1.2) mm.; shape broadly oval or orbicular, seed proper frequently oriented at a slight angle in wing; color of seed proper orange-red, darker around edge of seed proper, wing yellow; seed coat reticulate-areolate; wing width 0.12 mm., reticulate-areolate; cotyledons accumbent. (Similar to *A. alpina*.)

Distribution: Virginia and Kentucky to Florida and Texas, north to Ohio, Indiana, Illinois, Kansas and Nebraska; also in southern California.

Material studied: Ill. (F); Ind. (Kb); Mo. (FPI), (FSL), (ISC).

Seed illustrated: Jackson Co., Mo., April 25, 1897, ISC 23116, K. K. Mackenzie.

53. *MYAGRUM PERFOLIATUM* L. Sp. Pl. 640. 1753

Fig. 92

Fruit: Length 5-6 mm., width 3.5-4.0 mm. in broadest portion; color light tan; fruit coat bony, almost smooth; 3-celled but 1-seeded.

Seed: Length (2.0)-2.2-(2.2) mm., width (1.0)-1.1-(1.1) mm.; shape oblong or broadly oval; color orange; seed coat in part areolate, punctulate and pubescent; beak prominent and longer than cotyledonary side; cotyledons incumbent.

¹ See Rollins' (1941) monograph on the transfer of *Arabis virginica* to the genus *Sibara*.

Distribution: Quebec, naturalized from Europe.

Material studied: France (F); Quebec (US).

Seed illustrated: Paris, France, F. 788112, Jeanpert.

54. *ISATIS TINCTORIA* L. Sp. Pl. 670. 1753

Fig. 90

Fruit: Length (1.0)-1.6-(2.2) cm., width (4.0)-4.5-(5.5) mm. in broadest portion; shape oblong to cuneate at one end; color tan; fruit coat lineolate in part; 1-seeded and seed attached apically; major part of fruit wing-like.

Seed: Length (2.7)-2.9-(3.0) mm., width (0.9)-0.9-(1.0) mm.; shape narrowly oblong to columnar-terete, may or may not be tapering at apex; color orange; seed coat punctulate to rough, occasionally pubescent at base; radicular ridge prominent; cotyledons incumbent.

Distribution: Locally common in grain fields and gardens throughout the United States. Introduced from Eurasia.

Material studied: Calif. (F); Wash. D. C. (FSL); Peru (F).

Seed illustrated: Siskiyou Co., Calif., June 7, 1910, F 279572, Geo. D. Butler.

Remarks: Plant once cultivated in France for the blue dye obtained from the leaves.

55. *CHEIRANTHUS CHEIRI* L. Sp. Pl. 661. 1753

Fig. 77

Length (2.2)-2.9-(3.5) mm., width (1.4)-1.4-(1.7) mm.; shape oval or ellipsoid; color of seed coat orange, of wing yellow; seed coat punctulate, rough or rugulose; wing width on sides 0.2-0.3 mm., at apex 0.5-0.7 mm., frequently faintly banded apically; primary groove deep and irregular; hilar area double-banded; cotyledons accumbent.

Distribution: Native of Europe, cultivated in United States and occasionally escaping.

Material studied: France (F); Wash. D. C. (FSL).

Seed illustrated: Dieppe, France, 1902, F 816895, Jeanpert.

56. *IODANTHUS PINNATIFIDUS* (Michx.) Steud. Nomend. ed. 2, 812. 1841

Fig. 34

Length (1.0)-1.3-(1.5) mm., width (0.8)-0.9-(1.0) mm.; shape broadly oblong; color dark red; seed coat and wing falsifoveate; wing present at apex and base; primary groove distinct at base only, nearly centrally placed; cotyledons accumbent.

Distribution: Native to northeastern and southeastern United States.

Material studied: Tenn. (US); Okla. (US); Penn. (US); Ill. (F).

Seed illustrated: Nashville, Tenn., Aug. 30, 1877, US 136286, L. F. Ward.

57. *HESPERIS MATRONALIS* L. Sp. Pl. 663. 1753

Fig. 81

Length (2.1)-2.5-(3.0) mm., width (1.0)-1.1-(1.3) mm., thickness (0.9)-0.9-(1.1) mm.; shape oblong, beveled, ellipsoid, columnar, frequently inner side is flat and outer side transversely ridged; color reddish-brown; seed coat alveolate, ocellate, ribbed or rough (in illustration, a rough coat); texture of seed coat has a woody appearance; cotyledons incumbent.

Distribution: Northeastern United States and Canada. Escaped from cultivation. Introduced from Europe.

Material studied: Penn. (P); Ind. (PSL); Canada (PSL).

Seed illustrated: Ottawa, Canada, PSL, 1930.

58. *MATTHIOLA INCANA* (L.) R. Br. Ait. Hort. Kew ed. 2, 4: 119

Fig. 74

Length (1.4)-1.7-(2.0) mm., width (1.7)-1.9-(2.0) mm.; shape orbicular to broader than long; color orange to brownish black; seed coat granulate, frequently whitish substance coating parts of the seed coat; wing width 0.3 mm. or over, cream-colored, surrounding seed but very fragile and breaking off, obscurely banded in part; both inner and outer sides frequently have several small slant faces; cotyledons accumbent.

Distribution: Occasionally escaped from cultivation in northeastern United States. A native of Europe.

Material studied: N. Y. (FSL); Guatemala (F).

Seed illustrated: New York, FSL, Peter Henderson.

Remarks: It was this species which inspired Miss Saunders to carry on her provocative floral morphological studies.

59. *BRAYA HUMILIS* (C. A. Meyer) Robinson. Gray & Wats.

Syn. Fl. 1: 141, in part. 1895

Fig. 15

Length (0.8)-1.0-(1.1) mm., width (0.4)-0.6-(0.7) mm.; shape ellipsoid to oblong, base of the cotyledonary side thinner appearing as a darker appendage; color orange streaked with red; seed coat alveolate, glebulate and punctulate in part, glassy in appearance; three grooves; cleft and crest prominent; cotyledons incumbent.

Distribution: Quebec, Vermont, Lake Superior.

Material studied: Vt. (BUT); Quebec (F).

Seed illustrated: D'Anticosti, Quebec, Aug. 12, 1926, F 728411, FF Marie-Victorin and Rolland-Germain.

60. *BRAYA LONGII* Fern. Rhodora 28: 202. 1926

Length (1.2)-1.3-(1.5) mm., width (0.6)-0.6-(0.7) mm.; shape sub-oblong, radicular side much longer than cotyledonary side; color dark red; seed coat favulariate to almost smooth, not glassy in appearance; cotyledons incumbent.

Distribution: Newfoundland.

Material studied: Newfoundland (F).

61. *CHORISFORA TENELLA* (Willd.) DC. Syst. 2: 435

Fig. 89

Fruit: Length 3.0 cm. (average), beak approximately one-third of the length, width 2 mm. or less; 9-10 jointed.

Seed: Length (1.4)-1.4-(1.6) mm., width (0.7)-0.8-(1.0) mm.; shape narrowly oval; color green-yellow; seed coat punctulate, lineolate, scalariform; radicular side longer than cotyledonary side; cotyledons accumbent.

Distribution: Sporadic throughout the United States.

Material studied: Ia. (ISC); Mass. (US); Wash. (US).

Seed illustrated: Woodbury Co., Iowa, May 15, 1930, ISC 136038, B. O. Wolden.

62. *SELENIA AUREA* Nutt. Journ. Acad. Phila. 5: 132. 1825

Fig. 82

Length (2.7)-2.9-(3.1) mm., width (2.4)-2.7-(2.9) mm.; shape orbicular to sub-orbicular; color seed proper orange, wing yellow; seed coat reticulate, interspaces wider on wing than on seed coat; cleft empty; cotyledons accumbent.

Distribution: In sandy habitats; Missouri, Kansas, Texas.

Material studied: Ind. (2 stations) (F), (US); Mo. (2 stations) (US), (F); Kans. (US); Ark. (F).

Seed illustrated: Northwest Arkansas, May, 1900, F 206426, F. L. Harvey.

63. *LUNARIA ANNUA* L. Sp. Pl. 653. 1753

Fig. 94

Lunaria biennis Moench.

Fruit: Length 4 cm. or over; shape broadly oval; color light tan, septum white; fruit coat reticulate-veined, parchment-like, septum smooth and glossy.

Seed: Length (8.0)-8.4-(8.5) mm., width (6.8)-7.0-(7.0) mm.; shape reniform; color light brown to grayish brown; seed coat and wing reticulate, with a very low reticulum, also rugose; wing width 1.0-1.3 mm.; three or four dark lines meeting near the hilar area; cotyledons accumbent.

Distribution: Escaped from cultivation in northeastern United States and Canada.

Material studied: Va. (US); Conn. (US); Columbia (F); Europe (US).

Seed illustrated: Lynchburg, Va., US 1241478, R. R. Monroe.

64. *LUNARIA REDIVIVA* L. Sp. Pl. 653. 1753

Fruit: Length 4 cm. or over; shape elliptic, pointed at both ends; color light brown, septum white; fruit coat reticulate-veined, parchment-like, septum smooth and glossy.

Seed: Length (9.5)-10.0-(10.0) mm., width (7.6)-8.0-(8.0) mm.; shape reniform; color dark brown; seed coat reticulate with a very low reticulum, interspaces elongate on wing, not on seed proper; wing width 1.0-1.2 mm.; two double-banded dark streaks meeting at the hilar area; cotyledons accumbent.

Distribution: Escaped from cultivation in northeastern United States and Canada. Introduced from Europe.

Material studied: Europe (3 stations) (FPI), (F).

65. *BERTEROA INCANA* (L.) DC. Syst. 2: 291. 1821

Fig. 64

Length (1.7)-1.7-(1.9) mm., width (1.4)-1.6-(1.7) mm.; shape orbicular, less frequently ovoid; color brown with a hoary cast; seed coat areolate, cuticle and mucilage abundant; wing thick and coriaceous, width 0.1-0.2 mm., usually wider on radicular side, sometimes absent or rim-like on portions of the seed's edges; cotyledons accumbent.

Distribution: Maine to Ontario and Minnesota, south to Missouri. Naturalized from Europe.

Material studied: Ill. (SPR), (US); Ia. (ISC), A. Hayden; Mont. (US); Minn. (US); Mich. Murley.

Seed illustrated: Dickinson Co., Iowa, July 31, 1947, Plant No. 7. A. Hayden.

Remarks: Mass collection: colony of 20 plants, Van Buren Co., Michigan, July 18, 1948, Jane Rollers; colony of 8 plants, Dickinson Co., Iowa, July 31, 1948, A. Hayden; colony of 9 plants, Palo Alto Co., Iowa, August 3, 1948, A. Hayden.

66. *BERTEROA MUTABILIS* (Vent.) DC. Syst. 2: 292. 1891

Fig. 66

Alyssum mutabile Vent.

Length (1.3)-1.4-(1.5) mm., width (1.1)-1.2-(1.3) mm.; shape ovoid or orbicular, if orbicular with beveled faces on outer side; color dark reddish brown; seed coat areolate; wing width 0.15, usually not as wide as in *B. incana*; cotyledons accumbent.

Distribution: Reported from Massachusetts and New York. Naturalized from Europe.

Material studied: N.Y. (US); Mass. (US).

Seed illustrated: New York, August 17, 1934, US 1679673, True.

67. *ALYSSUM ALYSSEOIDES* L. Syst. ed. 10, 1130. 1759

Fig. 49

Alyssum calycinum L.

Length (1.2)-1.3-(1.5) mm., width (0.8)-0.9-(1.0) mm.; shape obovoid or broadly oval, plump and rounded in general contour; color orange; seed coat minutely tuberculate; wing surrounding seed, lobulate at base, thick not transparent, areolate 0.1 mm. in width; groove variable as to depth, may be deep throughout its entire length, may be shallow and indistinct toward the apex; cotyledons accumbent.

Distribution: Massachusetts, New York, New Jersey to Ontario, Iowa and the Far West. Naturalized from Europe.

Material studied: Calif. (US); Idaho (ISC); Ia. (ISCSL); N.C. (US); Ill. Murley.

Seed illustrated: Evanston, Ill., Aug. 5, 1947, M. Murley.

68. *LOBULARIA MARITIMA* (L.) Desv. Journ. Bot. 3: 192. 1813

Fig. 43

Konigia maritima (L.) R. Br.

Length (1.0)-1.4-(1.5) mm., width (0.9)-1.0-(1.1) mm.; shape oval (flatter than *alysseoides*); color orange; seed coat minutely tuberculate; wing minutely tuberculate, not as wide or as thick as in *A. alyssoides*, absent or extremely narrow on radicular side; cotyledons accumbent.

Distribution: Escaped from cultivation, in northeastern United States and Canada and on the Pacific Coast. Introduced from Europe.

Material studied: Fla. (2 stations) (P), (US); Calif. (US).

Seed illustrated: California, Sept. 24, 1913, US 1620852, Frank Johnson.

69. *DRABA ARABISANS* Michx. var. *CANADENSIS* (Brunet) Fern. & Knowl.

Rhodora 7: 67. 1905

Length (1.0)-1.5-(1.6) mm., width 0.6 mm.; shape oval; color dark orange; seed coat punctulate, rough in part; cotyledons accumbent.

Distribution: Newfoundland, Quebec, Michigan.

Material studied: Conn. (FPI); Quebec (3 stations) (US).

70. *DRABA BRACHYCARPA* Nutt. T. & G. Fl. N. A. 1: 108. 1838

Fig. 19

Length (0.5)-0.6-(0.8) mm., width (0.3)-0.4-(0.5) mm.; shape sub-oval, pointed at apex, frequently angular or beveled on the radicular side; color yellow, darker at the edges; seed coat obscurely areolate; cotyledons accumbent.

Distribution: Virginia to Illinois, Missouri, Kansas; in the south Florida to Texas; and the Far West in Oregon.

Material studied: Va. (US); Mo. (US); Ark. (US); Ala. (US); Ind. (3 stations) (Kb.); Ill. (SPR).

Seed illustrated: Indiana, May 12, 1940, Kb. 8626, R. Kriebel.

71. *DRABA CUNEIFOLIA* Nutt. T. & G. Fl. N. A. 1: 108. 1838

Fig. 16

Length (0.8)-0.9-(1.1) mm., width (0.5)-0.6-(0.6) mm.; shape broadly oval; color yellow orange; seed coat pustulate; claws evident; cotyledons accumbent.

Distribution: Southern Illinois, Missouri, Kansas, Colorado; Florida to Texas.

Material studied: Tex. (2 stations) (US); Mo. (2 stations) (US), (FPI).

Seed illustrated: Allenton, Mo., April 1879, US 127454, Letterman.

¹ See Fernald's (1905, 1934) articles on *Draba* in which seed characters are used in his keys.

72. *DRABA FLADNIZENSIS* Wulf. var. *HETEROTRICHA* (Lindblom.) Ball.
Bull. Soc. Bot. Fr. 7: 230. 1860

Length (1.1)-1.1-(1.2) mm., width (0.6)-0.6-(0.7) mm.; shape: (a) narrowly obovoid, and (b) ovoid; color dark brown, black at base; seed coat rough; two conspicuous funicular appendages, cleft prominent; cotyledons accumbent.

Distribution: Arctic regions south to Hudson Bay, Labrador, Canadian Rocky Mt.; northern Eurasia.

Material studied: Baffin Is. (F); Gaspé (2 stations) (US), (F)

73. *DRABA GLABELLA* Pursh var. *MEGASPERMA* Fern. & Knowlt.
Rhodora 36: 337. 1934

Draba megasperma Fern. & Knowlt.

Length (0.8)-1.1-(1.3) mm., width (0.5)-0.7-(0.7) mm.; shape oval to short oblong, occasionally a wing tip; color yellow; seed coat rough; cotyledons accumbent.

Distribution: Labrador, Newfoundland, New Brunswick, Quebec.

Material studied: Quebec (2 stations) (F), (US); Newfoundland (US).

74. *DRABA LANCEOLATA* Royle. Engler, Pflanzenr. IV, 105: 296. 1927

Draba stylaris Fern. & Knowlt.

Length (0.7)-0.9-(1.0) mm., width 0.5 mm.; shape oval; color orange, lustrous; seed coat punctulate; cotyledons accumbent. (Close to *D. arabisans*; differentiating characters such as length of seed and color are not always reliable.)

Distribution: Eastern Quebec to Yukon, New Hampshire, Michigan, Wisconsin, Colorado, Utah.

Material studied: Quebec (US); N.H. (US).

75. *DRABA NEMOROSA* L. Sp. Pl. 643. 1753

No characters could be found to distinguish this species from *D. reptans*.

Distribution: Western North America east to South Dakota and Manitoba, occurring locally in western Ontario and Michigan; Eurasia.

Material studied: Minn. (US); N.D. (US); Manitoba (US); Idaho (US).

76. *DRABA RAMOSISSIMA* Desv. Journ. Bot. 3: 186. 1814
Fig. 47

Length (1.2)-1.4-(1.6) mm., width (0.8)-0.9-(1.0) mm.; shape oval, apiculate; color deep orange; seed coat granulate, areolate in part; hilar area banded; cotyledons accumbent.

Distribution: Virginia, Kentucky, Tennessee, North Carolina.

Material studied: Va. (2 stations) (US), (F).

Seed illustrated: Virginia, August 15, 1937, US 1765021, H. A. Allard.

77. *DRABA REPTANS* (Lam.) Fern. Rhodora 36: 368. 1934
Fig. 18

Draba caroliniana Walt.

Length (0.5)-0.6-(0.6) mm., width (0.3)-0.4-(0.4) mm.; shape oval rounded at apex; color light yellow or light orange; seed coat punctulate; beak curving toward the cotyledonary side; cotyledons accumbent.

Distribution: Throughout the United States, southern Ontario.

Material studied: Ia. (ISC); Ill. (F); Ind. (3 stations) (SPR), (Kb.); Ark. (US); Okla. (US); Ga. (US).

Seed illustrated: Mitchell, Indiana, May 24, 1935, Kb. 3134, R. Kriebel.

78. *DRABA VERNA* L. Sp. Pl. 642. 1753

No reliable characters could be found to distinguish this species from *D. reptans*. The seed is darker in color on the average.

Distribution: Massachusetts to Ohio, Kentucky, Tennessee, British Columbia to California. Naturalized from Europe.

Material studied: W. Va. (US); Md. (Kb.); Ind. (3 stations) (Kb.); Wash. (US).

79. *DIPLLOTAXIS MURALIS* (L.) DC. Syst. 2: 634. 1821

Fig. 29

Length (1.0)-1.0-(1.2) mm., width (0.7)-0.8-(0.9) mm.; two distinct shapes: (a) strongly compressed and folded (false primary groove), sub-oblong, one claw lying in part upon another, (b) slightly compressed, narrowly obovoid; color orange in early stages of seed coat differentiation, gray when completely differentiated; seed coat in (a) is striate and favulariate, in (b) punctulate. Although in (a) the seeds were collected later in the growing seed than in (b), both are viable; beak curving toward cotyledonary base; mucilaginous envelope develops when placed in water; cotyledons conduplicate. in the Far West. Naturalized from Europe.

Distribution: Nova Scotia to Ontario, New England States to the Great Plains. Naturalized from Europe.

Material studied: W. Va. (US); Md. (Kb.); Ind (3 stations) (Kb.); Wash. (US).

Seed illustrated: Waukegan State Park, Ill., M. Murley, A—Sept. 4, 1948, B—Aug. 5, 1948.

Remarks: Mass collection from a colony of 25 plants, Waukegan State Park, Ill., Aug. 5, and Sept. 4, 1948, M. Murley.

80. *DIPLLOTAXIS TENUIFOLIA* (L.) DC. Syst. 2: 632. 1821

Very similar to *D. muralis*. The beak is frequently straight rather than curved. No mucilaginous envelope develops when placed in water.

Distribution: Nova Scotia to Ontario, New England to Pennsylvania, Indiana, and in the Far West. Naturalized from Europe.

Material studied: N. J. (US); Calif. (US); Mass. (FSL).

81. *BRASSICA*¹ *CAMPESTRIS* L. Sp. Pl. 666. 1753

Fig. 71

Dimensions 1.4-2.0 mm.; shape spheroidal, or slightly compressed laterally; color gray or reddish gray; seed coat with distinct reticulations and stipples, stigmaticose both in the interspaces and on the reticulum; cotyledons conduplicate. (Wild turnip.)

81a. *BRASSICA CAMPESTRIS* L. var. *RAPA* (L.) Hartm.

Handb. Skand. Fl. 6 ed. 110. 1854

Fig. 70

B. rapa L.

Difficult to distinguish from the above. (Cultivated turnip occasionally escaping.)

82. *BRASSICA HIRTA* Moench. Rhodora 40: 306. 1936

Fig. 67

B. alba (L.) Rabenh.

Diameters average 3.0 mm., laterally compressed to spheroidal; color light yellow to light brown; alveolate; cotyledons conduplicate.

¹ For more detailed descriptions and distributions on *Brassica* sp. see Bailey (1922) and Musil (1948).

83. *BRASSICA JUNCEA* (L.) Cosson. Bull. Soc. Bot. Fr. 6: 609. 1859
Fig. 68

Diameters 1.2-1.7 mm.; spheroidal; color brownish-red and gray; reticulate, reticulum fine and distinct, 4-, and 5-sided with netting or indistinctly stigmaticose in the wide interspaces; cotyledons conduplicate.

84. *BRASSICA KABER* (DC.) Wheeler var. *PINNATIFIDA* (Stokes) Wheeler
Rhodora 28: 202. 1926
Fig. 72

B. arvensis (L.) Rabenh.

Dimensions 1.4-1.7 mm.; shape spheroidal; color red or black; seed coat reticulate but obscure at magnifications of $\times 30$ or under; cotyledons conduplicate.

85. *BRASSICA NIGRA* (L.) Koch. Roehl, Deutsche Fl. ed. 3, 4: 713. 1833
Fig. 69

Dimensions 1.1-1.4 mm.; shape sub-spheroidal; red and grayish-brown; seed coat reticulate, with a prominent thick reticulum, 5-, and 6-sided, indistinctly stigmaticose in the interspaces; cotyledons conduplicate.

86. *ERUCA SATIVA* Mill. Gard. Dict. ed. 8, No. 1. 1768
Fig. 79

Length (1.7)-1.9-(1.9) mm., width (1.2)-1.3-(1.4) mm., thickness (0.6)-0.6-(0.7) mm.; shape oval, rounded contour, broader apically, laterally compressed; color orange or gray; seed reticulate-areolate; two black lines running parallel to the primary groove; cotyledons conduplicate.

Distribution: Escaped from cultivation in the eastern and north central states and eastern Canada. Introduced from Eurasia.

Material studied: N. Y. (US); Wash. D. C. (FSL); France (FSL).

Seed illustrated: France, FSL.

87. *ERUCASTRUM GALLICUM* (Willd.) O. E. Schulz. Engler's Bot.
Jahrb. 54. Beibl. 119: 56. 1916
Fig. 44

E. Pollichii Schimp. & Spenn.

Length (1.2)-1.3-(1.3) mm., width (0.7)-0.7-(0.8) mm.; shape oval-oblong, slightly flattened; color reddish orange; seed coat alveolate with elongated interspaces; seed sometimes lying with lateral side uppermost showing the prominent radicular ridge and two smaller ridges on either side; cotyledons conduplicate.

Distribution: In grain fields in the Dakotas and Minnesota and in Canada, occasionally in the northeastern states and eastern Canada. Introduced from Europe.

Material studied: Wash. D. C. (FSL); N. D. (F); Minn. (MSL).

Seed illustrated: Fargo, N. D., 1911, F 689243, Stevens.

88. *RAPISTRUM RUGOSUM* (L.) All. Fl. Pedem. 1: 257. 1785
Fig. 93

Fruit: Length averaging 5.0 mm., width of upper joint averaging 2.0 mm., of lower joint 1.2 mm.; shape of upper joint turbinate, lower joint cuneate; color grayish tan; fruit coat of upper joint ridged and sulcate, areolate, of lower joint areolate.

Seed: Length (1.5)-1.6-(1.8) mm., width (0.8)-0.8-(0.9) mm.; shape oblong; color light orange; seed coat areolate; smaller ridge on either side of the radicular ridge; cotyledons conduplicate.

Distribution: Around eastern seaports, Pennsylvania. Introduced from Europe.

Material studied: Ind. (PSL); Chile (FSL); Palestine (F).

Seed illustrated: Indiana, Purdue Seed Laboratory, Lafayette, Indiana.

89. *CAKILE EDENTULA* (Bigel.) Hook. Fl. Bor. Am. 1: 59. 1833

Seeds were not available.

89a. *CAKILE EDENTULA* (Bigel.) Hook. var. *LACUSTRIS* Fern. 1 Rhodora 24: 23. 1922

Fig. 91

C. americana Millsp.

Fruit: Length 2 cm. or less, width 0.5 cm. or less; two jointed, upper joint larger, ovoid to conical, lower joint obovoid, joints 1-seeded, sometimes lower joint seedless; color olive tan; fruit coat alveolate.

Seed: Length (4.3)-5.2-(5.7) mm., width (1.7)-2.5-(2.8) mm. (seed smaller on the average in lower cells: see chapter on mass collections); shape narrowly oval to ellipsoid; color light tan, faintly mottled; seed coat punctulate to almost smooth; inner side with two prominent grooves and a depression; cotyledons accumbent.

Distribution: Newfoundland, New Jersey to Florida, Great Lakes and Minnesota. Also on the California coast.

Material studied: Calif. (FPI); Ill. (F), Murley; Mich. (P), Murley.

Seed illustrated: Waukegan, Ill., Oct. 1, 1947, Plant No. 1, M. Murley.

Remarks: Mass collections—colony of 12 plants, Waukegan State Park, Ill., Oct. 1, 1947; colony of 13 plants, Warren Sand Dunes, Berrien Co., Mich., Oct. 9, 1948.

90. *RAPHANUS RAPHANISTRUM* L. Sp. Pl. 669. 1753

Fig. 87

Fruit: Length variable depending on number of joints, width 3.5 mm.; color light brown to greenish tan; 4-8 jointed, longitudinally grooved; each joint containing one seed embedded in spongy tissue.

Seed: Length (2.1)-2.2-(2.5) mm., width (1.5)-1.7-(1.9) mm.; seed sub-oblong and pointed at base or occasionally sub-globose; color brownish-red; seed coat alveolate, the interspaces elongate; tri-ridged, prominent radicular ridge, smaller ridge on either side; prominent configuration in the hilar region; cotyledons conduplicate.

Distribution: In grain fields of the northeastern states and Canada; also in the Pacific Northwest. Introduced from Europe.

Material studied: Ala. (ISC); Minn. (MSL).

Seed illustrated: Minnesota, MSL.

91. *RAPHANUS SATIVUS* L. Sp. Pl. 669. 1753

Fig. 85

Fruit: Length 3-8 cm. variable depending on the number of joint-like constrictions, width 5.0-9.0 mm.; shape cylindrical and tapered at apex; color grayish tan; fruit coat nearly smooth; spongy tissue within fruit, drying up somewhat at maturity.

Seed: Length 3.0-3.5 mm., width 3.0-3.4 mm.; shape sub-globose, occasionally short oblong or sub-ovoid, slightly flattened at various angles; three longitudinal ridges, the two narrower ones on either side of the radicular ridge; color light orange to reddish brown; seed coat reticulate-areolate, alveolate in spots; conspicuous configuration in the hilar area; cotyledons conduplicate.

Distribution: In grain fields in the Pacific Coast states and locally common in the Lake Ontario region. Introduced from Europe. An escape of the garden radish.

Material studied: Calif. (P); N. Y. (US); Seed Co. (9 sources) (ISCSL).

Seed illustrated: Woodruff and Sons Seed Co., Atlanta, Georgia, 1947.

1 See Fernald's (1922) article on "Some Variations of *Cakile edentula*."

92. CONRINGIA ORIENTALIS (L.) Dumort. Fl. Belg. 123. 1827

Fig. 78

Length (1.9)-2.1-(2.5) mm., width (1.0)-1.2-(1.5) mm., thickness 0.9 mm.; shape oblong, only slightly flattened, almost as thick as broad; color brownish red or reddish tan; seed coat ocellate when fully differentiated, alveolate in earlier stages; cotyledons incumbent occasionally obliquely incumbent.

Distribution: In grain fields of Ontario, Manitoba, Minnesota, Iowa and the northwestern states. Introduced from Europe.

Material studied: Wash. D. C. (FSL); Ind. (Kb.); Minn. (MSL); Ia. (ISCSL), (ISC).

Seed illustrated: Wheat fields, Kossuth Co., Iowa, Oct. 1942, ISCSL.

93. LEPIDIUM CAMPESTRE (L.) R. Br. Ait. Hort. Kew. 4: 88. 1812

Fig. 61

Length (2.0)-2.1-(2.1) mm., width (1.1)-1.2-(1.3) mm.; shape obovoid, slightly angled pointed at base; color red to grayish black darkening with age; seed coat tuberculate and aculeate frequently encrusted with mucilage; radicular ridge conspicuous as a wide wedge; cotyledons incumbent.

Distribution: Well established throughout the United States. Introduced from Europe.

Material studied: Penn. (BUT; Ind. (BUT), (Kb.); N. Y. (BUT); Ia. (ISCSL).

Seed illustrated: Skokie Lagoon, Glencoe, Ill., July 11, 1948, Plant No. 13, M. Murley.

Remarks: Mass collection, a colony of 25 plants, July 11, 1948, Skokie Lagoon, Glencoe, Ill.

94. LEPIDIUM DENSIFLORUM Schrad. Ind. Sem. h. Gotting 4. 1832

Lepidium neglectum Thell. *Lepidium apetalum* of early American authors in whole or in part.

Externally, no reliable characters could be found to differentiate this entity from *L. virginicum*. The primary groove is usually shorter and does not extend horizontally but this is a highly technical mark useful to the expert. The best character is the incumbent cotyledons.

Distribution: In Canada and United States east of the Rocky Mountains. Naturalized from Europe.

Material studied: N. Mexico (US); Mont. (US); Ia. (ISC); Wash. D. C. (FSL).

95. LEPIDIUM LATIFOLIUM L. Sp. Pl. 644. 1753

Fig. 37

Length (1.0)-1.1-(1.1) mm., width (0.5)-0.6-(0.6) mm., thickness 0.35 mm.; broadly oblong to broadly oval; color deep orange; seed coat alveolate, minutely tuberculate at periphery; cotyledons incumbent.

Distribution: In New England in saline soil, also in sections of Mexico. Introduced from Europe.

Material studied: Mo. (F); Mex. (F); Colo. (US); Conn. (US).

Seed illustrated: Durango, Mexico, 1896, Edward Palmer.

96. LEPIDIUM PERFOLIATUM L. Sp. Pl. 643. 1753

Fig. 41

Length (1.9)-1.9-(2.1) mm., width (1.1)-1.2-(1.3) mm., thickness 0.55 mm.; shape oval; color brownish red; seed coat areolate; conspicuous brownish black line curving in

the form of a hook following the primary groove and in part the secondary groove; wing may completely surround seed, or be reduced or absent on the cotyledonary side of seed, areolate, cream-colored; cotyledons incumbent.

Distribution: Central and western United States. Naturalized from Europe.

Material studied: Utah (BUT); Nebr. (BUT); Idaho (BUT); Nev. (FPI); Ia. (ISC).

Seed illustrated: Iowa, ISC, Lounsbury.

97. *LEPIDIUM RUDERALE* L. Sp. Pl. 645. 1753

Fig. 38

Length (1.3)-1.4-(1.4) mm., width 0.7 mm., thickness 0.35 mm.; shape narrowly obovoid; color orange; seed coat glebulate, punctulate in part; primary groove deep one-third the length of the seed; cotyledons incumbent.

Distribution: Common in northeastern United States and in Nova Scotia and occurring in Texas. Naturalized from Europe.

Material studied: Ala. (US); N. Bruns. (FPI); Tex. (US).

Seed illustrated: New Brunswick; June 21, 1900, US 432853, Fowler.

98. *LEPIDIUM SATIVUM* L. Sp. Pl. 644. 1753

Fig. 60

Length (2.7)-2.8-(3.0) mm., width (1.4)-1.5-(1.7) mm.; shape oval frequently slightly eccentric at apex; color reddish-orange; seed coat areolate; primary groove deep, secondary groove indistinct and forked marking the bifid or trifid cotyledons; slight cleft; cotyledons incumbent and either bifid or trifid lobed.

Distribution: Escaped from cultivation. A European species.

Material studied: Ill. (US); Smyrna (FPI); England (FSL).

Seed illustrated: England, Jan. 3, 1940, FSL, H. Cull.

99. *LEPIDIUM VIRGINICUM* L. Sp. Pl. 645. 1753

Fig. 40

Length (1.4)-1.5-(1.6) mm., width (0.9)-0.9-(1.0) mm., thickness 0.25 mm.; shape narrowly obovate to oval, flat, wafer-like; color light orange; seed coat minutely tuberculate; wing width 0.1 mm., absent on cotyledonary side, minutely tuberculate; primary groove bending near apex and extending a short distance horizontally; cotyledons accumbent, incumbent or oblique.¹

Distribution: Eastern United States and Canada, to Iowa, the Dakotas and Texas.

Material studied: Ia. (ISC); Ind. (Kb.); Wash. D. C. (FSL); Fla. (US); Va. (US); Calif. (US); Mo. (FSL); Ill. Murley.

Seed illustrated: Evanston, Ill., July 28, 1948, Plant No. 3, base of raceme, M. Murley.

Remarks: Mass collections: a colony of 25 plants, separate collections from base and apex of raceme, July 28, 1948 and August 6, 1948, Foster Street, garden lot, Evanston, Ill.; a colony of 20 plants, rock pile, near city incinerator, July 31, 1948, Wilmette, Ill.

100. *CARDARIA DRABA* (L.) Desv. Journ. Bot. 3: 163. 1814

Fig. 57

Lepidium Draba L.

Length (1.7)-1.8-(1.9) mm., width (1.1)-1.1-(1.3) mm., thickness 0.5 mm.; shape oval, slightly compressed, flat; color orange red; seed coat granulate; cotyledons incum-

¹ See Hitchcock's (1936, 282) paper on "The genus *Lepidium* in the United States," in which he recognizes varieties in this genus using the cotyledonary character.

bent. (Fruit regarded as indehiscent but here treated as dehiscent.) Similar to *C. pubescens*.

Distribution: Widely distributed throughout North America. Naturalized from Europe.

Material studied: Utah (ISC); Calif. (F), (FSL); Ia. (ISCSL); Ore. (F); Minn. (MSL).

Seed illustrated: California, Oct. 11, 1939, FSL, Margaret Bellue.

101. *CARDARIA PUBESCENS* (C. A. Meyer) Jarm. var. *ELONGATA* Rollins.

Rhodora 42: 306. 1940

Hymenophyssa pubescens C. A. Meyer.

No reliable differentiating characters could be found to differentiate this species from *C. draba*.

Distribution: California, Idaho, Colorado, Wyoming, Michigan. Reported to have entered the country as impurities in alfalfa seed.

Material studied: Calif. (US); Idaho (US).

102. *CORONOPUS DIDYMUS* (L.) Sm. *Fl. Brit.* 3: 691. 1800

Fig. 86

Carara didyma (L.) Britt.

Fruit: Indehiscent; broader than long, length 1.9-2.2 mm., breadth 2.0-2.4 mm.; shape notched at apex, each valve sub-globose; color tannish yellow; fruit coat rugose.

Seed: Length (1.0)-1.1-(1.4) mm., width (0.7)-0.8-(1.0) mm.; shape cochleate; color light yellow; seed coat reticulate-areolate and lineolate; primary and secondary grooves deep; cotyledons incumbent, and transversely folded, the embryo bent at a slight angle at the cotyledonary node.

Distribution: The Atlantic Coast and southern states westward to the Pacific Coast. Introduced from Eurasia.

Material studied: Tex. (US); Calif. (US); Ala. (US); Fla. (US); Mass. (US); Va. (US); N. Jer. (US).

Seed illustrated: Norfolk Co., Va., June 16, 1923, US, H. B. Meredith.

103. *CORONOPUS PROCUMBENS* Gilib. *Fl. Lituan.* (2): 52. 1781

Fig. 88

Carara coronopus (L.) Medic. *Coronopus coronopus* Karst.

Fruit: Indehiscent; broader than long, length 2.5 mm., breadth 3.1 mm. (average); shape not notched at the apex, each valve hemispherical in general outline; color tannish yellow; fruit coat grossly rugose and the rugae tuberculate in part.

Seed: Length (1.4)-1.7-(1.7) mm., width (1.0)-1.1-(1.1) mm.; shape oblong-obovate, eccentric (or sub-cochleate); color light yellow; seed coat reticulate-areolate and lineolate; primary and secondary grooves indistinct; cotyledons incumbent, and transversely folded, the embryo bent at a slight angle at the cotyledonary node.

Distribution: Atlantic coast and California. Naturalized from Europe.

Material studied: N. C. (US); Fla. (US); N. Jer. (US).

Seed illustrated: Wilmington, N. C., 1885, US 224226, G. McCarthy.

104. *HUTCHINSIA PROCUMBENS* (L.) Desv. *Jour. Bot.* 3: 168. 1814

Fig. 25

Length ((0.4)-0.5-(0.5) mm., width (0.3)-0.4-(0.4) mm.; shape broadly oblong or broadly oval; color light yellow; seed coat punctulate, greasy in appearance; primary groove indistinct or absent; cotyledonary and radicular bases red; cotyledons incumbent or accumbent.

Distribution: Labrador to British Columbia and in the Pacific states; also native in Europe and Asia.

Material studied: Canada (2 stations) (F); Minn. (F).

Seed illustrated: Northwestern Newfoundland, Aug. 4, 1925, F 678535, Fernald & Long.

105. *IBERIS AMARA* L. Sp. Pl. 649. 1753

Fig. 76

Length (2.1)-2.5-(3.0) mm., width (1.4)-1.7-(2.0) mm., thickness 0.5 mm.; shape sub-oval or narrowly obovoid, plump with a smooth rounded contour; color of seed coat orange, color of wing cream; seed coat areolate, lineolate in part; wing absent on the straight or cotyledonary side, width averaging 0.15 mm. frequently wider and pointed at apex; cleft; a slight ridge sometimes running along the edge of the secondary groove; cotyledons incumbent.

Distribution: Occasionally escaped from cultivation in northeastern United States. Native of Europe.

Material studied: Penn. (P); Ia. (ISC); Honduras (F).

Seed illustrated: Iowa Hort. Gard., ISCSL, 1943, M. Murley

106. *COCHLEARIA OFFICINALIS* L. Sp. Pl. 647. 1753

Fig. 39

Length (1.1)-1.4-(1.6) mm., width (0.9)-1.0-(1.0) mm.; shape broadly oval to oval; color orange; seed coat verrucate, the verrucae irregular and enlarged apically, alveolate in early stages of differentiation; radicular side may be longer than cotyledonary side; peg-like stalk of funiculus frequently present at base of primary groove; cotyledons accumbent or obliquely incumbent.

Distribution: Along seacoasts in north temperate and arctic shores of Europe and North America.

Material studied: Alaska (F); Anticosti (F); Denmark (FSL).

Seed illustrated: Anticosti, Canada, Sept. 3, 1883, F 109223, Macoun.

Remarks: Used as an antiscorbutic remedy.

107. *THLASPI ARVENSE* L. Sp. Pl. 646. 1753

Fig. 58

Length (1.8)-2.0-(2.0) mm., width (1.1)-1.2-(1.4) mm.; shape broadly oval, eccentric on one side, straight edge thickest; color dark gray to black; an all over rugose appearance is caused by the following structures on the seed coat, ribs granular concentrically arranged around the periphery becoming parallel near the center, furrows wider than rib and lineated transversely; cotyledons accumbent.

Distribution: An introduced European species well established in eastern and central North America.

Material studied: Ia. (ISCSL); Ill. (ISM); Ind. (Kb.); Nev. (FPI); China (FPI).

Seed illustrated: Illinois, roadside Skokie Lagoons, Glencoe, July 4, 1948, Plant No. 10, M. Murley.

Remarks: Mass collection: colony of 25 plants, July 4, 1948, Skokie Lagoons, Glencoe, Ill., M. Murley.

108. *THLASPI PERFOLIATUM* L. Sp. Pl. 646. 1753

Fig. 22

Length (1.0)-1.1-(1.3) mm., width (0.6)-0.8-(1.0) mm.; shape obovoid, frequently eccentric; color light orange-tan; seed coat almost smooth to lineolate; emarginate on some of the edges; frequently partition tissue of fruit adhering to the seed; cotyledons accumbent.

Distribution: Locally common in Ontario, New York, Indiana. Introduced from Europe.

Material studied: Ky. (2 stations) (BUT); Tenn. (US); Va. (US); Ill. (F); Ind. (5 stations) (BUT), (IND).

Seed illustrated: Woodstock, Shenandoah Co., Virginia, US 1634718, Lena Artz.

109. *CAMELINA MICROCARPA* Andrz. DC. Syst. 2: 517. 1821

Fig. 42

Length (1.0)-1.1-(1.2) mm., width (0.6)-0.7-(0.7) mm.; shape oblong or narrowly oval slightly compressed; color burnished red; seed coat alveolate in the early stages of differentiation becoming verrucate; seed when placed in water develops a striated mucilaginous envelope; cotyledons incumbent.

Distribution: In grain fields, especially flax. Common in western Canada, Washington, coming into the eastern states. Naturalized from Europe.

Material studied: Ill. (F); Ill. (SPR); Ia. (ISCL); N. C. (US); Ky. (US); Mont. (US).

Seed illustrated: Stamping Ground, Ky., June 19, 1930, US 1464803, J. C. Singer.

110. *CAMELINA PARODII* Ibarra & La Porte. Rev. Arg. Agron. 14: 104. 1947

Fig. 52

Length (2.4)-2.5-(2.6) mm., width (2.0)-2.4-(2.5) mm.; shape mitiform, pulvinate-depressed; color light orange; tuberculate; cotyledons accumbent.

Distribution: Argentina, Paraguay, United States.

Material studied: Ia. (ISCSL); Minn. (MSL); Calif. (CSL); Ind. (PSL).

Seed illustrated: Iowa, 1940, ISCSL.

Remarks: Sporadic reports of its establishment in the United States. The seed has been mistaken for *C. sativa* var. *dentata*.

111. *CAMELINA SATIVA* (L.) Crantz. Stirp. Austr. 1: 18. 1762

Fig. 51

Length (2.1)-2.3-(2.6) mm., width (1.0)-1.3-(1.4) mm.; shape narrowly oval to ellipsoid and twisted conical; color light orange; seed coat tuberculate; radicular ridge raised, sometimes twisted, conspicuous; cotyledons incumbent.

Distribution: Nova Scotia to British Columbia, Pennsylvania to Kansas. Common as a weed in flax fields. Naturalized from Europe.

Material studied: Ia. (ISC); Mont. (US); Alberta (US); Ill. (F), (SPR).

Seed illustrated: Ankeny, Iowa, July 8, 1925, ISC 117405, L. M. Forman.

111a *CAMELINA SATIVA* (L.) Crantz var. *DENTATA* (Willd.) Ibarra & La Porte.
Rev. Arg. Agron. 14: 101. 1947

C. dentata Pers.

Not sufficient or authentic material. At present it is difficult to differentiate the variety from the species *C. sativa*.

112. *NESLIA PANICULATA* (L.) Desv. Journ. Bot. 3: 162. 1814

Fig. 84

Fruit: Length (1.9)-2.0-(2.2) mm., width (2.0)-2.1-(2.4) mm.; shape globose to turbinate; color tan to dark brown; coat alveolate, granules superimposed and irregularly scattered in the depressions and on the ridges.

Seed: Length (1.8)-1.8-(1.9) mm., width (1.0)-1.1-(1.1) mm.; shape ovoid with a prominent radicular ridge; color orange; seed coat punctulate; cotyledons incumbent.

Distribution: In grain fields, common in the northwestern states and western Canada; infrequent in the eastern states. Introduced from Europe.

Material studied: Ia. (ISCSL); Ind. (2 stations) (US), (FSL).

Seed illustrated: Clarke, Indiana, May 16, 1896, US 339293, L. M. Umbach.

113. *CAPELLA BURSA-PASTORIS* (L.) Medic. Pfl. Gatt. 1: 85. 1792

Fig. 10

Length (0.8)-0.9-(1.0) mm., width (0.3)-0.4-(0.5) mm.; shape oblong, base truncate frequently with a central notch, apex rounded; color orange-yellow, base of seed darker; seed coat areolate, in part scalariform; funicular material may be present in the form of two projections; primary groove lateral or central; secondary groove evident; cotyledons incumbent.

Distribution: Common throughout North America. Naturalized from Europe.

Material studied: Wash. D. C. (ISC); Minn. (ISC); Utah (ISC); Vt. (ISC); Tex. (ISC); Ore. (ISC); Ia. (ISCSL), (ISC); Ill. Murley.

Seed illustrated: Wash. D. C., May 21, 1904, ISC 84755, Agnes Chase.

Remarks: Mass collection, colony of 25 plants, July 4, 1948, Wilmette, Ill., M. Murley.

114. *CAPELLA RUBELLA* Reuter¹ Comptes-Rend. Soc. Haller 1853-54

No reliable seed characters have been found to differentiate this species from *C. bursa-pastoris*.

Distribution: Virginia northward to Labrador; also reported from the far West; native in Europe.

Material studied: Wash. (F); Wash. D. C. (F); Labrador (F); Va. (F); Switzerland (US).

115. *SUBULARIA AQUATICA* L. Sp. Pl. 642. 1753

Fig. 17

Length (0.9)-1.0-(1.1) mm., width (0.7)-0.7-(0.8) mm.; shape frequently angular on one side to cochleate; color orange; seed coat punctulate; primary groove nearly centrally placed; secondary groove deep, present on the cotyledonary side and part of the radicular side; cotyledons incumbent and transversely folded.

Distribution: In lakes of northeastern Canada, in northern Maine, New Hampshire and Vermont, to Ontario, Wyoming, British Columbia and northern California. Native to North America and Europe.

Material studied: Vt. (US); N. Hamp. (US); N. Y. (US); Mont. (US); Calif. (US).

Seed illustrated: Long Lake, Hamilton Co., New York, Aug. 24, 1933, US 1633518, Muencher & Clausen.

116. *LESQUERELLA GLOBOSA* (Desv.) S. Wats. Proc. Am. Acad. 23: 252. 1888

Fig. 48

Length (1.2)-1.2-(1.3) mm., width (1.1)-1.3-(1.3) mm.; shape hemispherical on outer side, frequently two beveled faces on inner side; color brownish red; seed coat granulate, glebulate and alveolate in part; cotyledons accumbent.

Distribution: Kentucky, Tennessee, Missouri.

Material studied: Ala. (US); Tenn. (US).

Seed illustrated: Tenn., 1886, US 221157, Gatteringer.

117. *LESQUERELLA GRACILIS* (Hook.) S. Wats. Proc. Am. Acad. 23: 253. 1888

Fig. 45

Length (1.6)-1.8-(2.0) mm., width (1.1)-1.4-(1.6) mm.; shape mitiform; color red brown; seed coat punctate; radicular ridge wider than in *L. ludoviciana*; cleft; outer side

¹ See Fernald's (1948) article on *Capsella rubella*.

rounded in contour, inner side with a depression along the groove; cotyledons accumbent.

Distribution: Prairies and in the Great Plains from Nebraska to Texas.

Material studied: Okla. (P); Texas (3 stations) (US), (F).

Seed illustrated: Texas, May 20, 1928, F 723190, Albert Ruth.

118. *LESQUERELLA LUDOVICIANA* (Nutt.) S. Wats. Proc. Am. Acad. 23: 252. 1888
Fig. 46

Lesquerella argentea (Pursh) MacM.

Length (1.4)-1.7-(2.0) mm., width (1.0)-1.3-(1.4) mm.; shape mitiform and apiculate; color orange brown; seed coat granulate, alveolate in part; radicular ridge narrower than *L. gracilis*; cleft; wing-like appendages at base; outer side rounded in contour, inner side with a depression around the groove; cotyledons accumbent.

Distribution: Great Plains from North Dakota, Wyoming, to Nebraska, also in Arizona.

Material studied: Wyo. (F), (US); Nebr. (US), (ISC).

Seed illustrated: Nebraska, 1893, US 219014, Fred Clements.

Mass Collection Studies

Seed characters are commonly regarded as constant, although this assumption has never been tested by adequate methods. As the Cruciferae represent a well circumscribed family, it is of interest to know how constant their seed characters really are. In order to test the reliability of seed dimensions and shapes as used in the keys and descriptions mass collections of seeds of selected species were made and analyzed. Sampling errors were avoided as far as possible, by keeping careful records of the sources from which the numerous seeds examined were obtained. In addition, seeds of the same species selected for mass collections in the Chicago area were also obtained from other areas of North America, usually from earlier years.

In the case of mass collections made in the Chicago area (see chapter, "Materials and Methods") the samples obtained were selected by first stretching a string across the area of the colony and tagging every fifth plant touching the string, thus avoiding a personal chance factor (Anderson, 1941). Later, when collecting the mature seeds from the tagged plants, material was selected from both base and apex of the raceme. The seeds from 25 plants in a colony occupying a small area (i. e. 40 by 20 yds.) and maturing at the same time probably live under similar environmental conditions.

Alliaria officinalis:—As even macroscopic examination disclosed that the seeds of *A. officinalis* differed considerably in length, measurements were made to see if position in fruit determined seed length (Table I, p. 58). One fruit (silique) from each of 25 plants growing in a colony of a small area was taken from the apex of the raceme, and seeds in each fruit measured in sequence from base (1st) to apex (20th). The number of seeds in each fruit varies from twelve to twenty. The greatest differences in length of seeds occur in Plant 13, the range being 2.5-3.6 mm., the smallest differences in length of seeds occurring in Plants 7 and 18 range 2.8-3.3 mm. and Plant 3 range 2.7-3.2 mm. No significant relationship is evident between length of seed and its position in the fruit. As examples: in Plant 12, the longest seed 3.5 mm. is 1st in position, the shortest seed 2.5 mm., 7th and 8th in posi-

tion, while seeds 2.6 mm. occupy 1st, 13th and apex positions; in Plant 7, the shortest seed 2.8 mm. is 1st, 7th and 9th in position, the longest seed 3.3 mm. is located at the apex.

Sisymbrium officinale var. *leiocarpum*.—The seeds of this variety are highly variable not only in length but in shape and color. A significant relationship was found between length of seed and its position in the fruit (Table II, p. 59). The shorter seeds are consistently at the base of the fruit, the longest seed at the apex of the fruit. As examples: in Plant 1, seed 1 (in the longer row), measured 1.0 mm., seed 8, 1.5 mm.; Plant 4, seed 1 (in the longer row), measured 0.9 mm., seed 9, 1.5 mm.; in Plant 14, seed 1 (in the shorter row), measured 0.9 mm., seed 7, 1.3 mm. In addition a significant relationship is found between the shape of the seed and its position in the fruit. The trapezoidal and beveled seeds are basal in position, the linear seed always at the apex and in the cell with the larger number of seeds. As examples: in Plant 1, seeds 1, 2, 3, 4 (in the longer row) and seeds 1, 2, 3 (in the shorter row) are beveled (Table II, Fig. C), and seed 8 is linear (F); in Plant 9, seeds 1 (in the longer row) and 1 and 2 (in the shorter row) are trapezoidal (G), seeds 2 and 3 (in the longer row) and seed 3 (in the shorter row) are beveled, (C) and seed 8 is linear (F).

Barbarea vulgaris.—Using seeds from several geographic areas and data based on seeds from other parts of the United States (Ind., Mo., N. Y., Penn., Iowa, Wash., D. C.), dimensions of seeds were measured (Table III, p. 60). The average median length is 1.3 mm., the average median width 1.1 mm. In addition, using mass collections from the Chicago area, a comparison was made between the dimensions of the seed and the position of the fruit on the raceme. Seeds from fruits collected at the base of the raceme are longer and broader than seeds from fruits at the apex of the raceme. As examples: In Plant 1—Base, the median length is 1.3 mm., in Plant 1—Apex, the median length is 1.1 mm.; in Plant 5—Base, the median length is 1.3 mm., in Plant 5—Apex, the median length is 1.1 mm.; in Plant 9—Base, the median length is 1.4 mm., in Plant 9—Apex, the median length is 1.1 mm.

Arabis canadensis.—Seeds of a winged species showed great variability in length and some in width. Measurements indicate that the wing rather than the seed proper is the variable structure.

Arabis laevigata.—Seeds of another winged species were measured in sequence from base to apex of fruit. No relationship is evident between the variability in dimensions and the position of the seed in the fruit. Here again the wing varies greatly in length.

Diplotaxis muralis.—Two distinct shapes, each with other distinctive characters, occur in the seeds of this species (Fig. 29-A-B, p. 72). The two types of seeds do not appear in the same fruit or on the same plant but occur in separate collections. Shape A is strongly compressed and folded (a false primary groove), sub-oblong, one claw lying in part upon the other; shape B is slightly compressed and obovoid. The collections of A were made

on September 4, those of B on August 5, 1949, both from the same colony in Waukegan State Park, Illinois. Both types were viable. Material studied from Iowa is of the A type, material studied from Wisconsin is of the B type. On the average type A is darker in color, usually gray, and the seed coat is a little further developed, being striate and favulariate, while in the case of type B the color is orange and the seed coat smooth to punctulate. Differences in seed characters of this species appear to be environmentally controlled.

Erysimum cheiranthoides.—Variable characters in this species are shape, seed coat, number of seeds in the fruit and presence or absence of a wing at the apex.

Several shapes have been delimited: conical, flat, twisted-conical, trapezoidal and ovoid (Fig. 50-A-F, p. 74). Unlike *Sisymbrium officinale* no relationship is evident between shape and position of seed in fruit.

Seed coats of seeds collected in early July are reticulate-areolate, while collections made in August from second growth plants are reticulate-areolate to minutely tuberculate and in places possess long hair-like mucilaginous strands. Seeds from both collections were viable. Dimensions of the seeds from the two collections do not vary significantly. It would appear that the environment is a factor in determining the extent of seed coat differentiation.

The variability in the number of seeds in a fruit is most striking between the natural sized and depauperate plants. The natural sized plants have longer racemes, longer fruits (range 1.25-1.5 cm.), and vary from 16 to 24 seeds in a fruit. Depauperate plants have shorter racemes, shorter fruits (range 0.5-1.0 cm.) and fewer seeds varying from 8 to 10 in a fruit. Here again the size of the seeds from the two collections does not vary significantly.

The presence of a wing at the apex is found on seeds from all collections and from various positions in the fruit.

Cakile edentula var. *lacustris*.—Considerable variation in the length and width of seeds of *Cakile edentula* can easily be seen on opening the fruits. Actual measurements gave the following data: length (4.3)-5.2-(5.7) mm., width (1.7)-2.5-(2.8) mm. By proceeding to measure the seeds from the upper and lower cells of the fruit separately, the data indicate that usually the larger seeds, particularly in their width, are located in the upper cell: upper cell, length (5.0)-5.3-(5.7) mm., width (2.4)-2.7-(2.8) mm.; lower cell, length (4.2)-4.7-(5.2) mm., width (1.7)-1.9-(2.1).

DISCUSSION

Apparently the fruits in which the seeds are borne significantly affect variability in many seeds. For instance, the size and shape of the seed appears to be related not only to position in fruit as noted in *Sisymbrium officinale*, but also to the shape of the fruit. In this species the terete silique may account in part for the linear elongated seed consistently occupying the extreme apex of fruit, while the shorter trapezoidal seeds are found in the

basal broader portion of the fruit. In contrast, *Erysimum cheiranthoides* belonging to a closely related genus, possesses a fruit more or less uniform in width throughout its length and is an example of a species in which the variability in shape of seeds cannot be explained by the shape of the fruit. Detling (1939, p. 485) made a similar observation when considering arrangement of seeds in the fruits of *Descurainia*: "Arrangement of seeds and shape of silique should be considered together since they are largely dependent upon one another." A similar relationship between seed and fruit occurs in Fernald and Knowlton's (1950, p. 67) key to the species of *Draba*: "Seeds not crowded, their edges rounded, and seeds closely crowded and overlapping, angulate." Thus in these areas heredity or environment or both may be playing a part in determining the characters of the seed but do so indirectly as the hereditary make-up of the fruit is the determining factor.

Somewhat conflicting statements similar to the following are seen in the literature "characters of seeds are generally constant" and "seed characters such as color, shape, markings are weak and not dependable." From data obtained by mass collection studies, the first statement surely is untenable in the case of the Cruciferae, and may apply equally well to other families, after their seeds have been studied critically.

Though the Cruciferae represent only one of the numerous families of seed plants, it is a large and well-defined family in which some constancy of character might be expected: yet considerable variation has been noted in the seed. This observation substantiates Schulz's (1936, p. 265) comment "the peculiarity of the family is that apparently very constant characters suddenly lose their constancy."

The validity of the second statement regarding the unreliability of seed characters is also questionable. Because seeds are small, usually more difficult to obtain than other plant parts and somewhat neglected, their characters are frequently considered unreliable and, when used to delimit entities, are often regarded as inferior to gross characters. But any real difference, no matter how small, has potential taxonomic value.

In approaching the problem of variability and constancy of seed characters from the broader viewpoint of plant taxonomy, the principle of using several or sometimes all plant characters in delimiting species or higher groups might well be used here. The seed, like any other organ of the plant, stands just as good a chance as another part to be useful taxonomically providing it meets the requirements expected of other characters. Therefore, in certain groups of plants or in certain species the seed may "prove" to be quite constant and highly reliable; in another group it may be highly variable and thus of little taxonomic value. Only by studying seeds in great detail and by increasing his accuracy by the use of mass collections will the taxonomist know in what groups the seed has taxonomic value.

TABLE I.—*Alliaria officinalis*: length of seeds (mm.) as related to position in silique.*

Seed No.		Plant No.	Silicles from apex of raceme Each column records length of seeds in mm. taken in sequence from base (1) to apex																				Colony of 25 plants Winnetka, Ill. July 15th, 1948																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
			#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15	#16	#17	#18	#19	#20	#21	#22	#23	#24	#25																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
1st	3.4	3.2	3.5	3.5	3.1	3.8	2.8	3.2	3.3	3.3	3.2	3.5	3.6	3.2	2.4	3.2	3.0	3.0	3.1	3.2	3.1	3.2	3.4	3.2	3.2																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

* Each column records the length of seeds from one fruit. The 25 fruits were selected one from each of 25 plants from the apex of the raceme. The first seed recorded is at the base of the fruit, the last seed at the apex. The numbers of seeds in the fruit varies from 12 to 26.

2.8 3.0 3.0 2.95 2.9 3.0 3.0 2.9 3.0 2.8 3.0 2.9 3.0 2.8 3.0 2.95 3.2 3.0

* Each column records the length of seeds from one fruit. The 25 fruits were selected one from each of 25 plants, from the apex of the raceme. The first seed recorded is at the base of the fruit, the last seed at the apex. The number of seeds in the fruit varies from 12 to 26.

TABLE II.—*Sisymbrium officinale* var. *leiocarpum*: Shape and length (mm.) of seed as related to position in silique.*

Seeds in two rows in silique recorded in sequence from base to apex

Colony of 25 plants, Evanston, Illinois, September 6, 1948

		Seeds																		
		A. Ridge, Apical									B. Ridge, Basal									
		C. Beveled									D. Flat									
		E. Twisted									F. Linear									
		G. Trapezoidal																		
Plant	Seeds	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	Median
1	O-O-O-O-O-A-A-A-F O-O-O-O-A-A-A-D	1.0	-1.1	-1.1	-1.0	-1.5	-1.5	-1.5	-1.5		1.1	-1.1	-1.1	-1.5	-1.5	-1.4				1.1
2	O-O-O-O-A-A-D-D-F O-O-O-O-E-D-E	1.1	-1.1	-1.1	-1.2	-1.2	-1.5	-1.5	-1.4		1.0	-1.1	-1.1	-1.5	-1.5	-1.2				1.15
3	O-G-O-G-C-E-D-D-D-A-F G-B-G-O-C-D-D-D-A	1.0	-1.1	-1.1	-1.2	-1.2	-1.5	-1.4	-1.4	-1.5	1.1	-1.2	-1.1	-1.1	-1.5	-1.5				1.2
4	O-G-O-G-B-E-D-D-D-D-F O-O-C-B-B-D-B-D-D-D	0.9	-1.0	-1.1	-1.2	-1.4	-1.5	-1.4	-1.4	-1.5	1.1	-1.1	-1.1	-1.2	-1.2	-1.5	-1.5	-1.5		1.2
5	O-O-O-O-O-D-D-D-D-F G-O-G-O-A-A-A-D	1.0	-1.0	-1.1	-1.1	-1.5	-1.5	-1.5	-1.4		1.0	-1.1	-1.2	-1.2	-1.5	-1.4	-1.4			1.2
6	O-O-O-B-E-B-D-D-D-F G-O-G-O-D-D-D-D	1.1	-1.1	-1.1	-1.2	-1.1	-1.4	-1.4	-1.5		1.0	-1.1	-1.2	-1.5	-1.5	-1.5				1.2
7	O-G-E-B-B-B-D-D-D-F O-O-C-O-C-B-B-D	1.0	-1.1	-1.2	-1.2	-1.5	-1.4	-1.4	-1.4	-1.4	1.0	-1.2	-1.2	-1.2	-1.4	-1.4	-1.4			1.25
8	O-O-A-A-A-D-D-D-F G-O-G-O-C-E-D	1.0	-1.0	-1.2	-1.2	-1.2	-1.5	-1.5	-1.4		1.0	-1.0	-1.1	-1.1	-1.2	-1.5				1.2
9	O-O-O-O-A-A-A-D-F G-O-G-O-B-B-B-D	1.0	-1.1	-1.1	-1.2	-1.2	-1.2	-1.5	-1.4		1.0	-1.1	-1.1	-1.2	-1.2	-1.2	-1.5			1.2
10	O-O-O-O-A-A-A-D-D-F O-O-C-O-C-B-B-D	1.1	-1.1	-1.1	-1.2	-1.2	-1.5	-1.5	-1.5	-1.4	1.0	-1.1	-1.1	-1.1	-1.2	-1.5	-1.5			1.2
11	O-O-O-O-B-B-D-D-D-F O-O-E-E-E-D-D-D	1.0	-1.1	-1.1	-1.2	-1.2	-1.2	-1.2	-1.2	-1.4	0.9	-1.1	-1.2	-1.2	-1.2	-1.5	-1.5			1.2
12	O-G-O-G-O-C-D-D-F G-A-A-A-A-A-A	0.9	-1.0	-1.0	-1.2	-1.2	-1.5	-1.5	-1.5		0.9	-1.1	-1.1	-1.1	-1.1	-1.1				1.1
13	O-G-O-O-A-A-B-D-F O-O-O-O-B-A-A-D	1.0	-1.0	-1.2	-1.2	-1.2	-1.2	-1.5	-1.5		1.1	-1.1	-1.2	-1.2	-1.2	-1.2				1.2
14	O-E-O-G-C-E-B-D-D-F G-O-A-A-A-A-A-D	1.0	-1.2	-1.1	-1.2	-1.2	-1.2	-1.5	-1.4	-1.4	0.9	-1.0	-1.2	-1.2	-1.2	-1.2	-1.5			1.2
15	O-O-O-A-A-A-D-D-F O-O-O-O-A-A-A-D	1.1	-1.0	-1.1	-1.1	-1.1	-1.1	-1.2	-1.2	-1.5	1.1	-1.1	-1.1	-1.2	-1.2	-1.2	-1.5			1.1
16	O-O-B-B-B-D-D-D-F G-O-G-O-C-D-D	1.0	-1.1	-1.2	-1.2	-1.2	-1.2	-1.5	-1.4		1.0	-1.0	-1.1	-1.2	-1.5	-1.5				1.2
17	O-O-C-O-A-D-A-A-F O-O-C-O-C-O-A-A-A	1.1	-1.1	-1.1	-1.2	-1.4	-1.2	-1.2	-1.4		1.1	-1.0	-1.1	-1.5	-1.4	-1.4	-1.4			1.2
18	O-O-O-G-E-E-D-D-D-F G-O-G-O-C-E-D-D-D	1.1	-1.1	-1.1	-1.2	-1.2	-1.5	-1.5	-1.5	-1.5	0.9	-1.0	-1.0	-1.1	-1.1	-1.1	-1.4	-1.4		1.1
19	O-O-O-O-G-A-B-D-A-F G-O-O-A-B-A-D-D-D	0.9	-1.0	-1.1	-1.2	-1.2	-1.2	-1.4	-1.2	-1.5	1.0	-1.0	-1.1	-1.1	-1.0	-1.5	-1.2	-1.5		1.2
20	O-G-E-B-B-B-D-D-F G-O-G-O-A-A-A-B	1.0	-1.0	-1.2	-1.1	-1.2	-1.5	-1.5	-1.5		0.9	-1.0	-1.0	-1.2	-1.2	-1.2	-1.2			1.2
21	O-O-O-O-D-D-D-D-D-F G-O-O-O-C-D-D-D	1.1	-1.1	-1.1	-1.1	-1.5	-1.5	-1.4	-1.4	-1.5	1.1	-1.0	-1.1	-1.1	-1.5	-1.5	-1.5			1.2
22	O-G-E-O-C-E-A-B-F G-O-G-O-D-D-D-D	1.0	-1.0	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.4	0.9	-1.0	-1.0	-1.2	-1.2	-1.2	-1.1			1.2
23	O-G-O-O-C-D-D-D-F B-E-E-O-C-D-D	1.0	-1.0	-1.1	-1.1	-1.2	-1.2	-1.2	-1.5		1.0	-1.2	-1.1	-1.5	-1.5	-1.5				1.2
24	O-E-O-G-E-E-A-B-A-F O-A-A-A-D-D-D-D	1.0	-1.2	-1.0	-1.0	-1.2	-1.5	-1.5	-1.5	-1.5	1.0	-1.2	-1.2	-1.2	-1.5	-1.5	-1.5	-1.4		1.2
25	O-O-A-A-A-A-A-C-F O-C-A-A-A-D-D-D	1.0	-1.1	-1.1	-1.1	-1.2	-1.2	-1.2	-1.5	-1.4	1.5	-1.5	-1.2	-1.2	-1.2	-1.5	-1.5	-1.5		1.2

* Left margin gives data on shapes of seeds, right margin gives data on measurements of the same seeds. Seeds in this species maintain two straight distinct rows in the fruit (silique) at maturity.

TABLE III.—*Barbarea vulgaris*: Length and width of seeds (mm.) as related to position on the plant.*

Length Range	Ind. (Murley) 1947			Mo. (US) 1906	N.Y. (US) 1915	Penn. (US) 1925	Iowa (ISC) 1925	Wash. D.C. (FSL)	Ill. (Murley) 1948											
	No. of Seeds								Base			Apex			Base			Apex		
	No. 1	No. 2	No. 3						1	2	3	1	2	3	1	2	3	1	2	3
1.0 mm.	-1	-0	-0	-0	-0	-1	-1	-0	-1	-3	-2	-2	-6	-0	-2	-0	-2	-0		
1.1 mm.	-3	-1	-3	-3	-3	-7	-3	-6	-4	-16	-6	-9	-9	-11	-3	-12	-3	-12		
1.2 mm.	-9	-8	-10	-6	-6	-11	-6	-8	-11	-5	-6	-8	-7	-9	-6	-8	-8	-8		
1.3 mm.	-8	-9	-10	-5	-8	-11	-5	-8	-11	-13	-2	-12	-2	-3	-11	-2	-8	-3		
1.4 mm.	-4	-5	-10	-0	-5	-0	-5	-5	-5	-0	-0	-0	-6	-0	-5	-0	-5	-5		
1.5 mm.	-0	-0	-0	-0	-5	-0	-5	-0	-0	-0	-0	-0	-0	-0	-0	-1	-0	-3		
Median	1.2	1.3	1.3	1.3	1.4	1.2	1.3	1.3	1.3	1.1	1.3	1.1	1.3	1.1	1.3	1.1	1.3	1.3		
Width																				
0.7 mm.	-0	-0	-0	-0	-0	-0	-0	-0	-0	-8	-1	-10	-0	-3	-0	-3	-0	-5		
0.8 mm.	-0	-0	-0	-3	-0	-0	-0	-3	-6	-14	-7	-14	-6	-20	-5	-21	-5	-15		
0.9 mm.	-1	-2	-1	-3	-10	-7	-4	-7	-13	-3	-13	-1	-7	-2	-6	-1	-13	-3		
1.0 mm.	-5	-9	-7	-8	-8	-16	-8	-5	-6	-0	-4	-0	-12	-0	-14	-0	-12	-2		
1.1 mm.	-18	-11	-15	-12	-4	-2	-12	-5	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0		
1.2 mm.	-1	-3	-2	-2	-0	-0	-1	-5	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0		
Median	1.1	1.1	1.1	1.1	0.9	1.0	1.1	1.0	0.9	0.8	0.9	0.8	0.9	0.8	1.0	0.8	0.9	0.9		
Length																				
1.0 mm.	-3	-2	-4	-0	-2	-0	-3	-0	-2	-0	-3	-0	-5	-1	-3	-0	-5	-0		
1.1 mm.	-13	-9	-8	-0	-10	-4	-10	-0	-11	-0	-10	-0	-10	-1	-7	-5	-9	-0		
1.2 mm.	-9	-8	-9	-6	-10	-7	-10	-7	-10	-8	-9	-8	-5	-9	-8	-5	-9	-5		
1.3 mm.	-0	-8	-4	-12	-4	-2	-2	-8	-2	-12	-3	-12	-3	-8	-7	-11	-2	-15		
1.4 mm.	-0	-1	-0	-5	-0	-8	-0	-6	-0	-5	-0	-5	-2	-4	-0	-4	-0	-5		
1.5 mm.	-0	-0	-0	-0	-0	-5	-0	-4	-0	-0	-0	-0	-0	-3	-0	-0	-0	-0		
Median	1.1	1.2	1.1	1.3	1.2	1.4	1.1	1.3	1.1	1.3	1.1	1.3	1.1	1.3	1.2	1.3	1.1	1.2		
Width																				
0.7 mm.	-4	-0	-4	-0	-2	-0	-4	-0	-3	-1	-6	-0	-5	-0	-6	-0	-4	-0		
0.8 mm.	-15	-4	-18	-0	-9	-0	-16	-2	-18	-7	-8	-8	-8	-7	-10	-5	-20	-0		
0.9 mm.	-6	-16	-2	-12	-5	-6	-4	-5	-6	-4	-8	-5	-6	-5	-7	-5	-0	-9		
1.0 mm.	-0	-4	-1	-12	-0	-12	-0	-12	-0	-4	-6	-6	-5	-7	-1	-6	-1	-4		
1.1 mm.	-6	-1	-0	-5	-3	-1	-0	-5	-0	-5	-0	-5	-3	-4	-0	-6	-0	-1		
1.2 mm.	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-3	-0	-0		
Median	0.8	0.9	0.8	1.0	0.9	1.0	0.8	1.0	0.8	0.9	0.8	0.9	0.8	0.9	0.8	1.0	0.8	1.0		

* Analysis of mass collections of seeds from seven localities. Seeds from base and apex of raceme of 15 plants were measured separately in the case of the Illinois collection.

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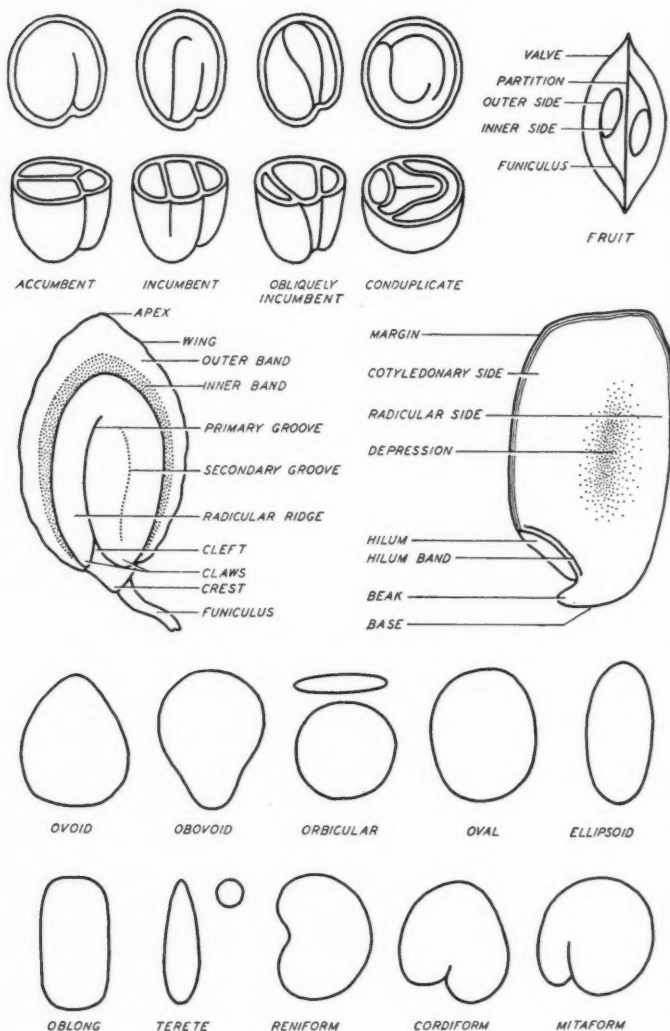


Fig. 1.—Illustrations of terms used in keys and descriptions.

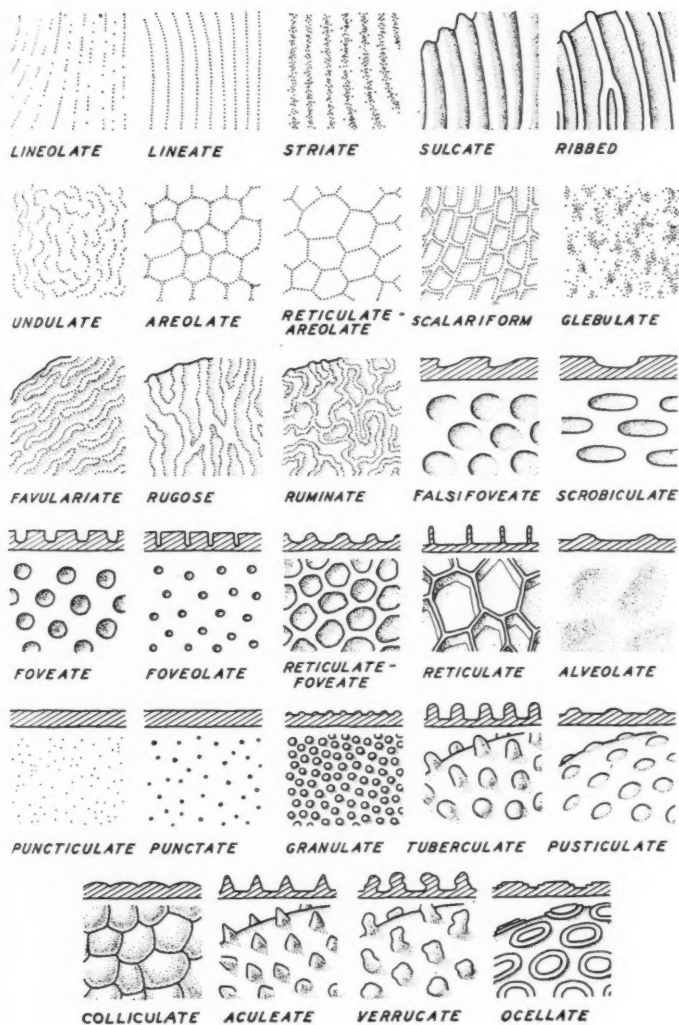
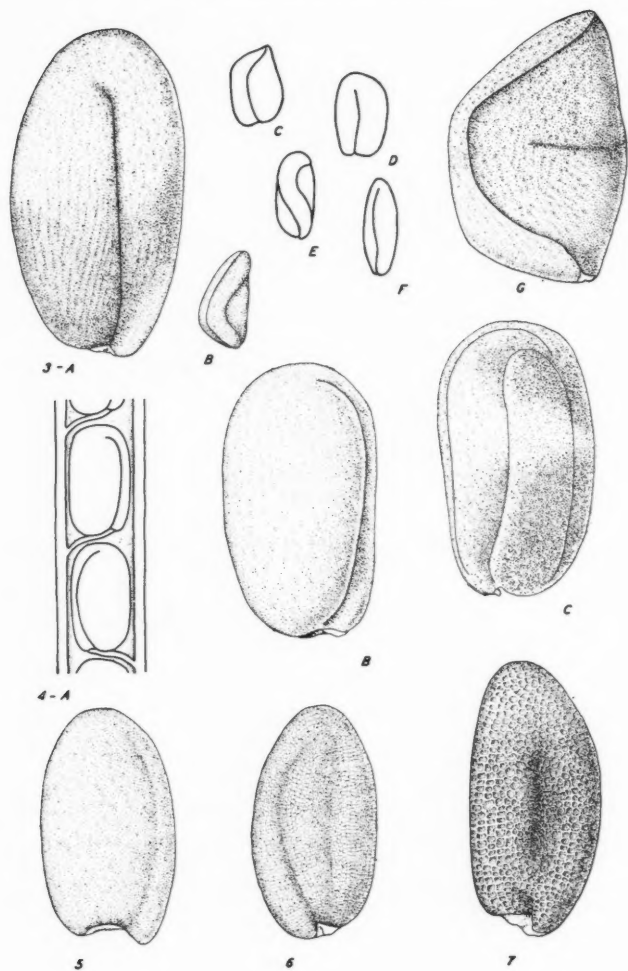
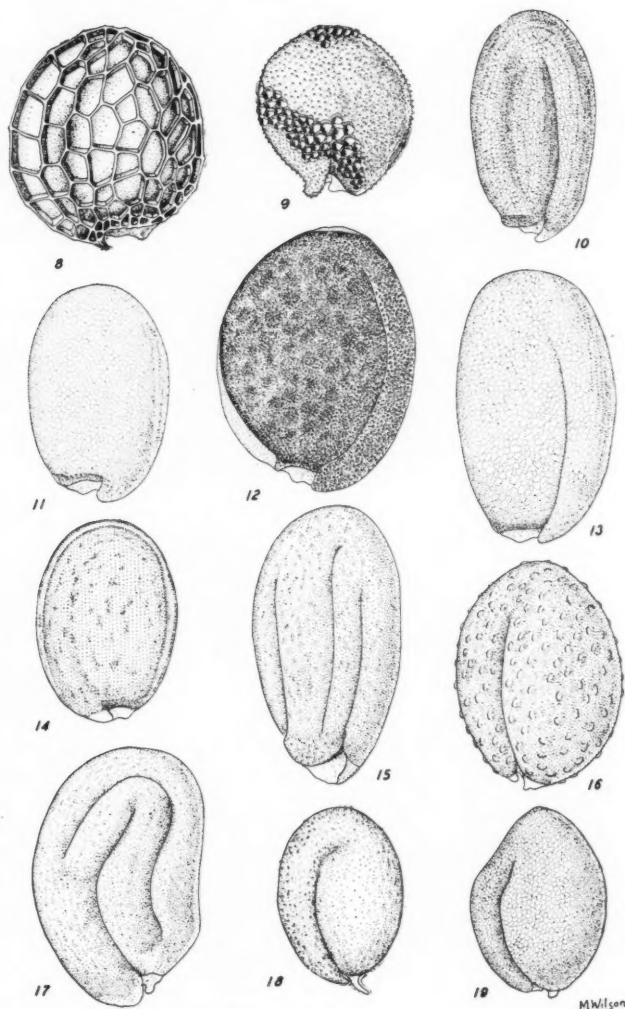


Fig. 2.—Illustrations of terms used in differentiating seed coats.

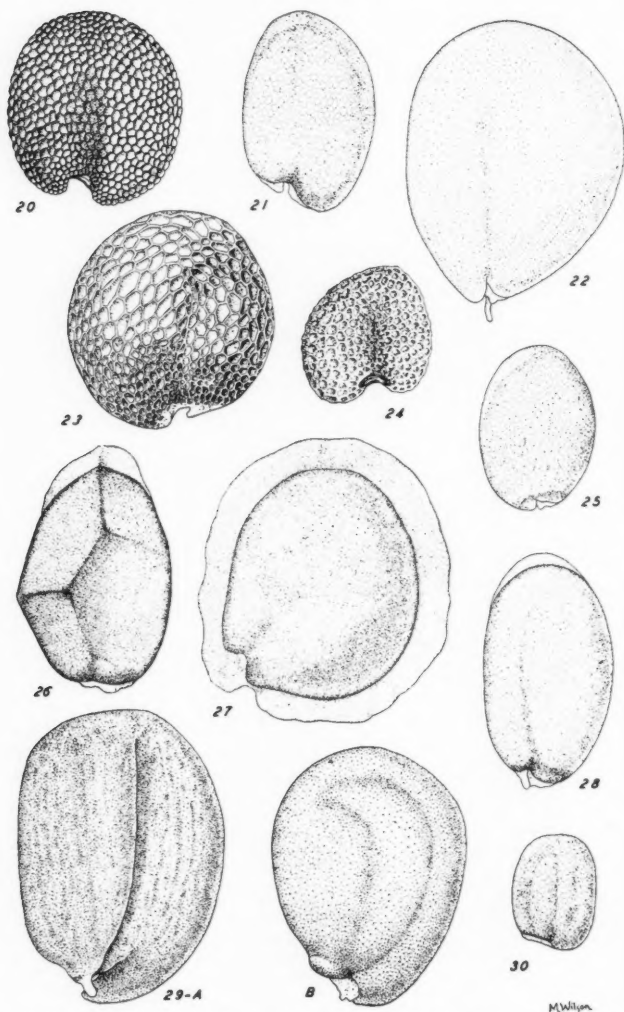


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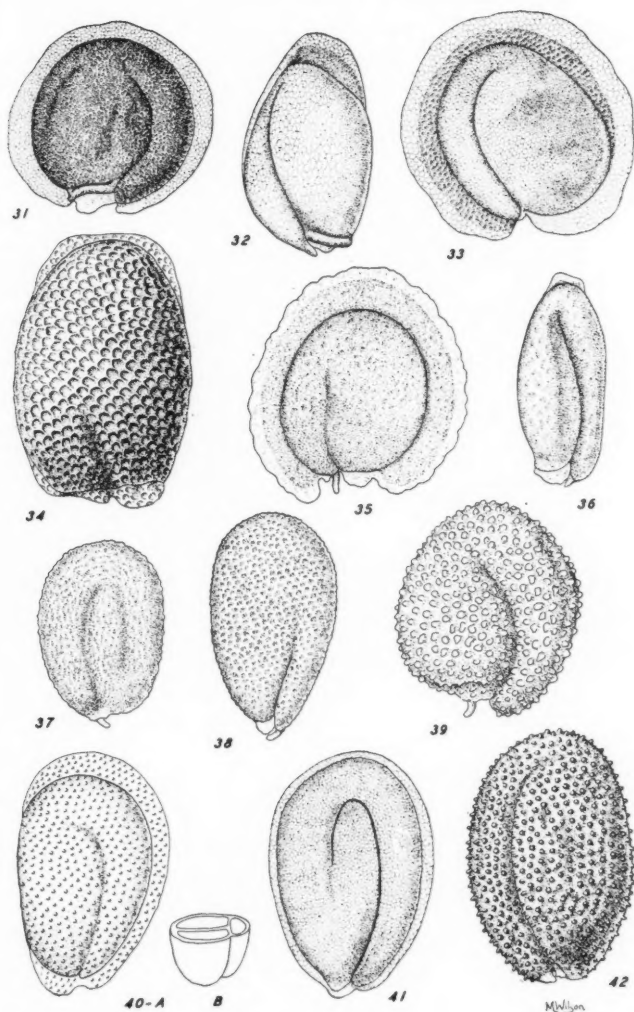


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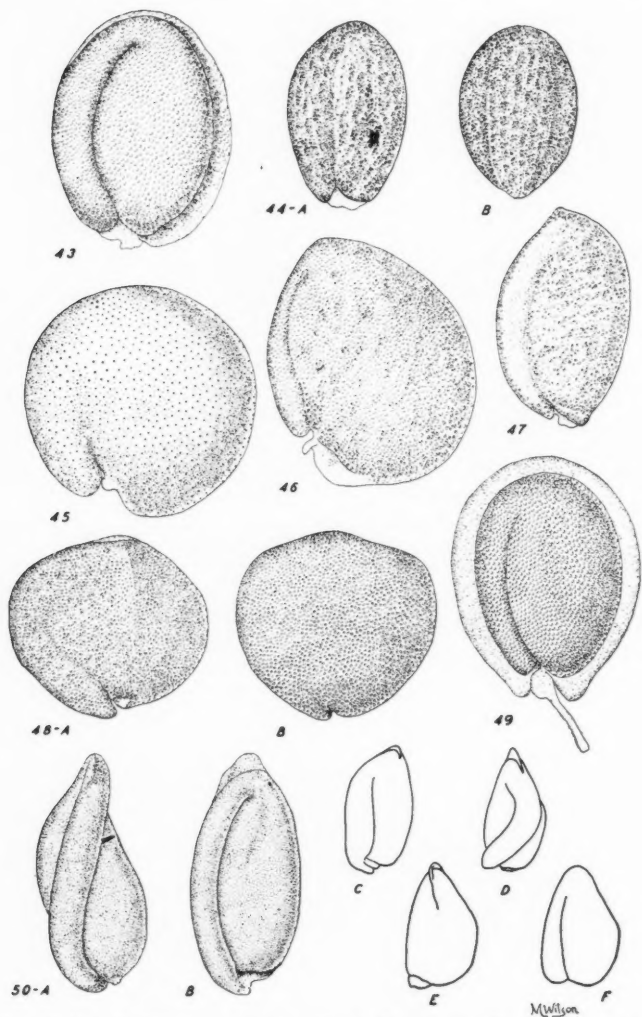


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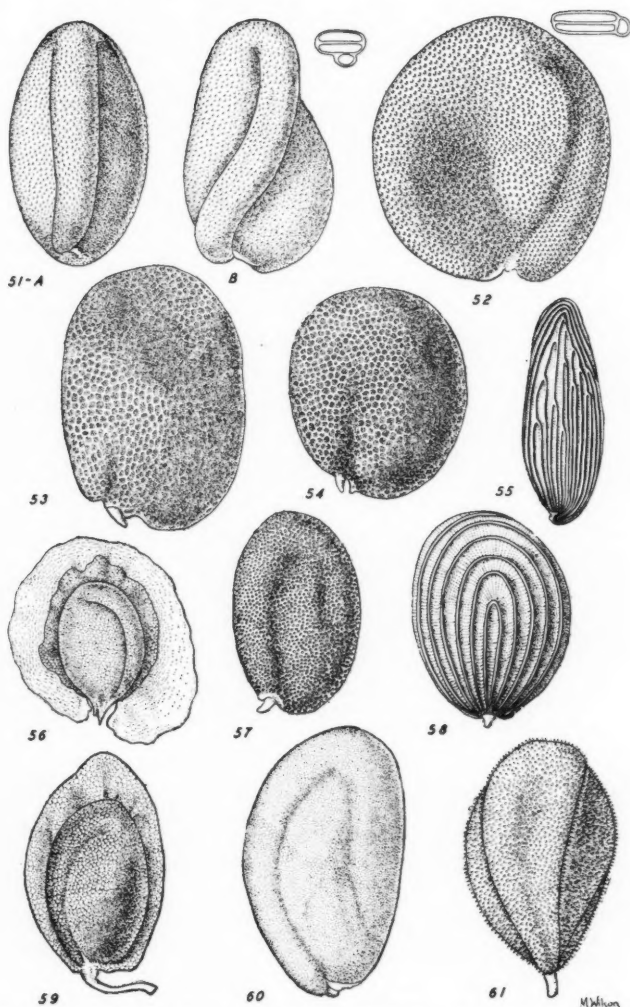
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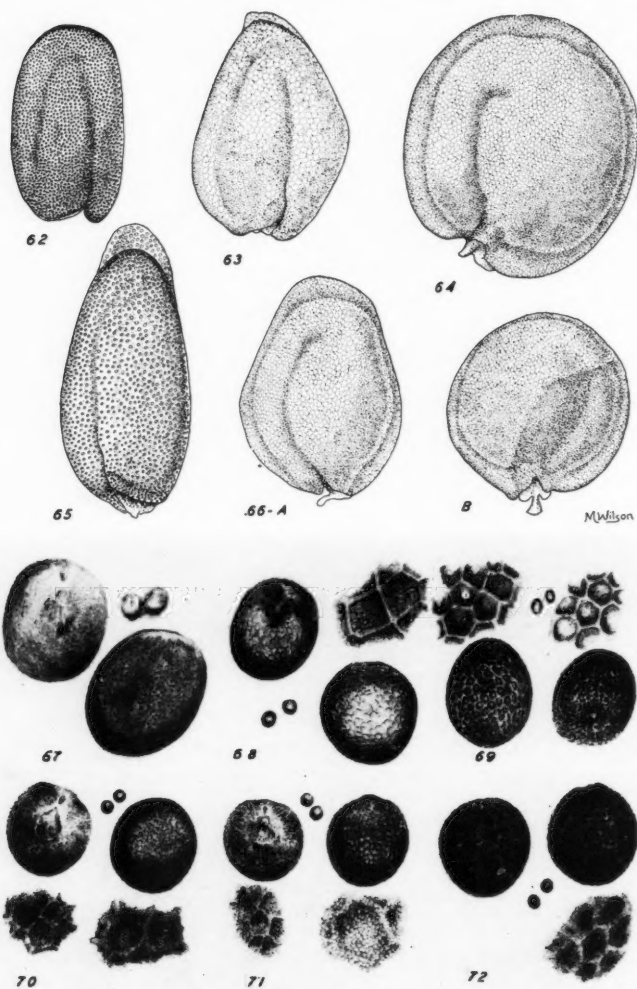
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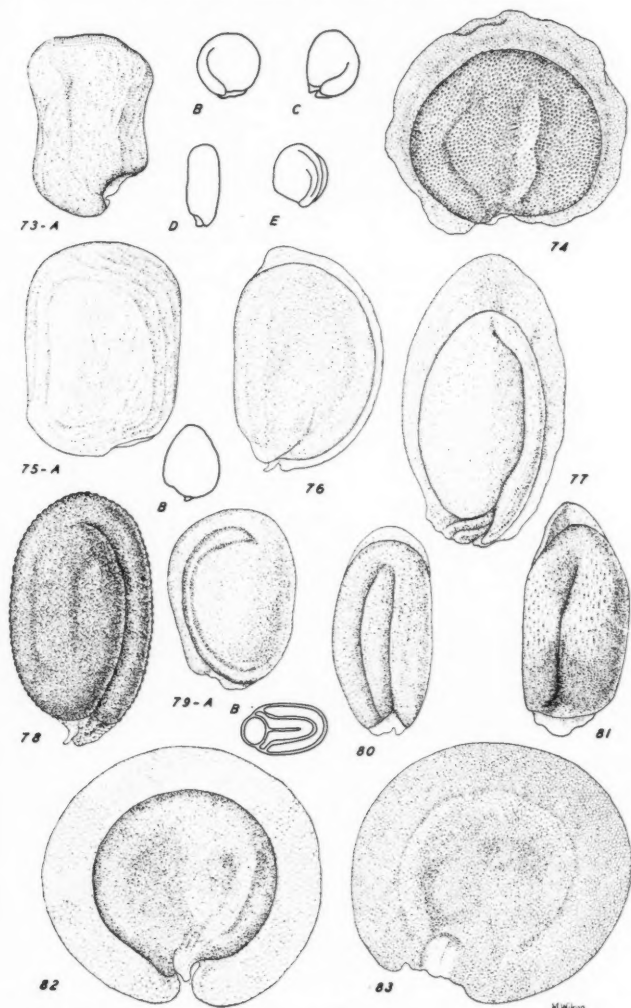
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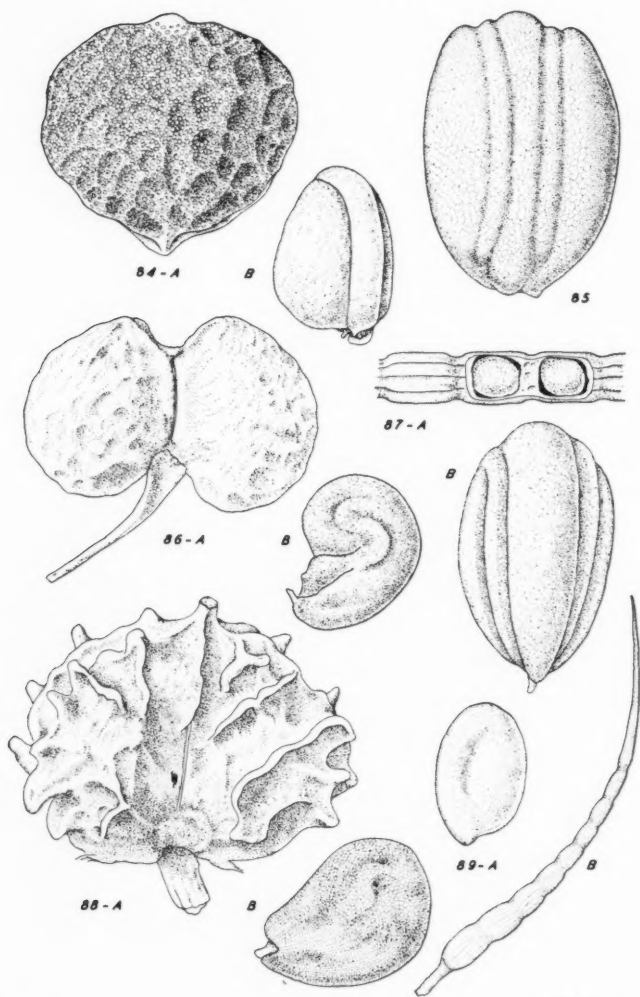
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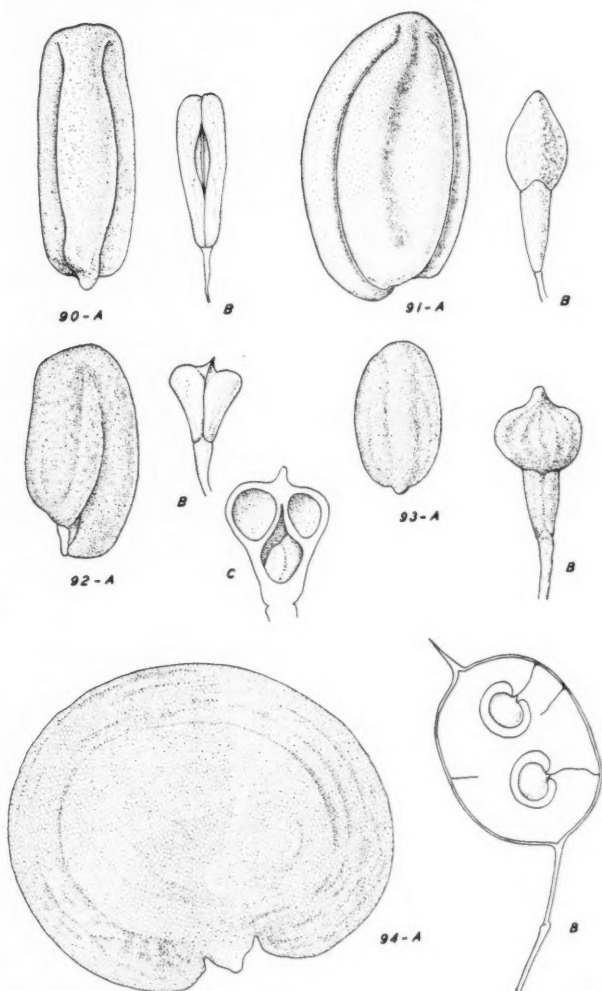


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		<i>Thlaspi perfoliatum</i>	51, 22
<i>Matthiola incana</i>	41, 74		

Revision of the United States Species of *Neptunia* (Leguminosae)*

B. L. Turner

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The genus *Neptunia* was first described by Loureiro in *Flora Cochinchinensis* 2: 653, 1790. He based it upon an aquatic species, *N. prostrata* (Lam.) Baillon (*N. oleracea* Lour.), from India, which is found in the tropical regions of North America, South America, and Asia. Loureiro was unaware that the plant had previously been described by Lamarck as a *Mimosa* (Encycl. 1: 10, 1783). *Neptunia* as delineated by Loureiro was distinguished primarily by the upper flowers of the heads containing anther-bearing stamens, while those of the lower are neuter, having petaloid stamino-odes (Loureiro thought them petals). The genus was placed near *Desmanthus* and *Dichrostachys* by some early taxonomists (De Candolle considered the latter genus and *Neptunia* no more than sections of *Desmanthus*), genera whose species often contain sterile filaments in the lowest flowers. Bentham (1842) noted the lack of constancy in this feature (e.g., *Neptunia lutea* has all its stamens anther-bearing) and placed *Neptunia* in his subtribe *Adenantherae*, which was distinguished from the subtribe *Gymnantherae* (containing *Desmanthus* and *Dichrostachys*) by having a small stipitate gland upon the anthers. Since then there has been no essential change in its generic status.

B. L. Robinson (1898) wrote a revision of the genus for the United States in which four species were listed as occurring within the continental limits. Britton and Rose (1928) accepted only two of these species, together with five others from Mexico and the West Indies. In the present paper four species and three varieties are recognized for the United States, including one new variety and two new records (*N. plena* and *N. Palmeri*). Instead of citing all specimens examined, distribution maps are offered. These provide a quicker summary of distribution as well as saving time and space.

ACKNOWLEDGMENTS

Grateful acknowledgment is made to Dr. Lloyd H. Shinnars, Director of the Herbarium of Southern Methodist University, for criticism of the manuscript and for financial aid in visiting the type locality of *Neptunia lutea*; to Dr. S. W. Geiser, Chairman of the Biology Department, Southern Methodist University, for assistance with early place names of critical importance; to Miss Nell C. Horner, Librarian of the Missouri Botanical Garden, for bibliographical assistance; and to Dr. R. M. Harper of the Alabama Geological Survey, Dr. Bernice G. Schubert of the Gray Herbarium, and Dr. Duane X. Isely of the Iowa State Seed Laboratory, for information concerning the distribution of *N. lutea*. I am indebted to the curators of the following herbaria for the loan of collections:

* Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, Southern Methodist University.

D Dudley Herbarium, Stanford University
 M Herbarium of the University of Michigan
 NY Herbarium of the New York Botanical Garden
 SMU Herbarium of Southern Methodist University
 T Herbarium of the University of Texas
 US United States National Herbarium

NEPTUNIA Loureiro, Fl. Cochinchinensis 2: 653. 1790.

Perennial herbs. Stems prostrate to erect, terrestrial or aquatic. Leaves bipinnate. Stipules membranous, obliquely cordate to broadly lanceolate. Petiole glandular or eglandular. Flowers sessile, rarely short-pedicelled, in dense capitate, ovate, or subcylindric spikes, the upper flowers with anther-bearing stamens, the lower with anantheriferous stamens (except *N. lutea*). Petals five, valvate, separate or joined to the middle. Calyx campanulate, 5-lobed. Style linear, exserted. Stigma truncate, concave. Stamens 10 or rarely 5, exserted, filiform; sterile stamens 10, petaloid (except *N. lutea*). Anthers 2-celled, bearing a small stipitate or sessile gland at apex between the cells. Legume variously shaped, flattened, 1- to many-seeded; valves persistently cohering along the margins. Peduncle solitary, bracteate (often inconspicuously so), elongate.

KEY TO U. S. SPECIES OF NEPTUNIA

- 1a. Petiole glandular (fig. 1); flowering peduncles bearing 2 large cordate bracts 4-8 mm. long, 3-5 mm. wide; leaflets without raised reticulate veins; plants aquatic or terrestrial 1. *N. plena*
- 1b. Petiole eglandular; flowering peduncles bearing 1 or 2 subulate bracts 1-3 mm. long, 1-2 mm. wide, or no bracts; leaflets with raised reticulate veins; plants terrestrial
 - 2a. Flowers in head with stamens all alike, anther-bearing; flower-heads when in bud with 30-60 flowers, subcylindric (fig. 2); stipe of pod 4-15 mm. long, (fig. 4); leaflets 8-18 pairs; calyx 1-2 mm. long (including lobes)
 - 3a. Pinnae 3-6 pairs 2a. *N. lutea*
 - 3b. Pinnae 6-11 pairs 2b. *N. lutea* var. *multipinnata*
 - 2b. Flowers in upper part of head with anther-bearing stamens, those in lower part smaller and with yellow (drying orange) petaloid staminodes; flower heads in bud with 20-30 flowers, ovoid (fig. 3); stipe of pod 0.4 mm. long (rarely 5 mm.); leaflets 10-35 pairs; calyx 2.0-2.7 mm. long (including lobes)
 - 4a. Pod oblong, 6-10 mm. wide; stipe 2-4 mm. long; pinnae 2-6 pairs; plants of Gulf Coastal region, south Texas to Florida
 - 5a. Leaflets conspicuously ciliate, most of the cilia 0.2-0.7 mm. long, the under-surface near apex conspicuously so; stipules covered with a scattered short pubescence; fruiting peduncles 2.5-7 cm. long; calyx lobes pubescent (10-20 cilia on each lobe); petals ciliate at apex 3a. *N. pubescens* var. *Lindheimeri*
 - 5b. Leaflets glabrous or sparsely ciliate, the cilia scarcely 0.2 mm. long, the under-surface completely glabrous or ciliate along the margin only; fruiting peduncles 6-11 cm. long; calyx glabrous or with but 4-5 hairs along the lobes; petals glabrous 3b. *N. pubescens* var. *floridana*
 - 4b. Pod broadly oblong, 10-16 mm. wide (fig. 5); stipe 0-2 mm. long; pinnae 2-3 (rarely 4) pairs only; plants of central and south-central Texas 4. *N. Palmeri*

1. *N. PLENA* (L.) Benth., Journ. Bot. 4: 355. 1842.

Mimosa plena L., Sp. Pl. 519. 1753. *Mimosa punctata* L., Syst. (ed. 10) 1311. 1758-59. (See remarks under *Desmanthus punctatus*, below.) *Desmanthus plenus* (L.) Willd., Sp. Pl. 4: 1045. 1806. *Desmanthus punctatus* (L.) Willd., Sp. Pl. 4: 1047. 1806. Listed as a synonym by Bentham and by Grisebach; originally from Jamaica. Jamaica specimens of *N. plena*, though generally more robust, do not seem separable. *Desmanthus polyphyllus* DC., Prod. 2: 444. 1825. (According to Bentham.) Habitat unknown. The only differentiating character given by De Candolle is "Foliola 30-40 juga." Robust specimens with 20-30 leaflets were seen from the West Indies (e.g., Martinique, P. Duss 831, April, 1883, US), but otherwise differed in no detail from *N. plena* as described below. *Acacia punctata* (L.) Desf., Cat. Hort. Par. 300. 1829. *Neptunia polyphylla* (DC.) Benth., Journ. Bot. 2: 129. 1840.

In addition to the above, Bentham lists as synonyms of this species *Mimosa adenantha* Roxb., *M. lycopodioides* Desf., *Acacia lycopodioides* (Desf.) Desv.; Grisebach lists *Neptunia surinamensis* Steud., *Desmanthus comosus* A. Rich.

Terrestrial, or the branches and leaves floating in quiet waters, but always anchored to the ground by a root. Glabrous or rarely minutely pubescent, branches prostrate to ascending. Stipules obliquely cordate, membranous, 4-10 mm. long, 3-6 mm. wide. Petioles 1-4 cm. long, with an orbicular to elliptic depressed gland 0.5-3 mm. long between the lowest pair of pinnae. Pinnae 2-4 pairs (rarely 5), 2-6 cm. long. Leaflets 10-30 pairs, 4-10 mm. long, 1.0-2.5 mm. wide, linear, obtuse or somewhat acute, smooth or faintly veined. Flowers dimorphic, in ovoid heads (upper ones with 10 anther-bearing stamens, lower ones smaller with petaloid staminodes); bracts about 2 mm. long, glabrous or sparsely ciliate; calyx 2-3 mm. long; petals 3-4 mm. long; sterile stamens petaloid, bright yellow (drying orange), lanceolate or linear-lanceolate, 0.5-2 mm. wide, 10-12 mm. long; anther-bearing stamens filiform, 6-10 mm. long. Fruiting peduncle 4-15 cm. long, bearing 2 conspicuous cordate or linear-cordate bracts on the lower half (bracts often falling with age). Legume 2.0-5.5 cm. long, 2-9 mm. wide, acute, apiculate or rounded, stipe 3-10 mm. long, exceeding the calyx; seeds 10-15 in each pod, transverse or strongly oblique.

The evidently floating stems contain an orange cork-like covering which is similar to that found on *N. prostrata* (Lam.) Baill., a floating plant found throughout the tropical regions of North America, South America, and Asia. Much taxonomic confusion has resulted from the peculiar growth this plant makes when found in water. Miller (Gard. Dict. 4th ed. vol. 2, 1754) eloquently phrases this in commenting on some plants "discovered by Dr. Houstoun at La Vera Cruz . . . it was growing in standing waters, and the branches were spread flat on the surface of the water in such manner, as if they floated but when it grows on dry ground the stalks grow erect, and the whole appearance of the plant is so much altered, as that some botanists have described it as two different plants; so this *Mimosa* has a very different appearance while the ground where it grows, is covered with water; but where the water dries up, and leaves the plants while they are young, they will grow erect; and those of them which have grown in England, have risen to the height of four or five feet; but they spread

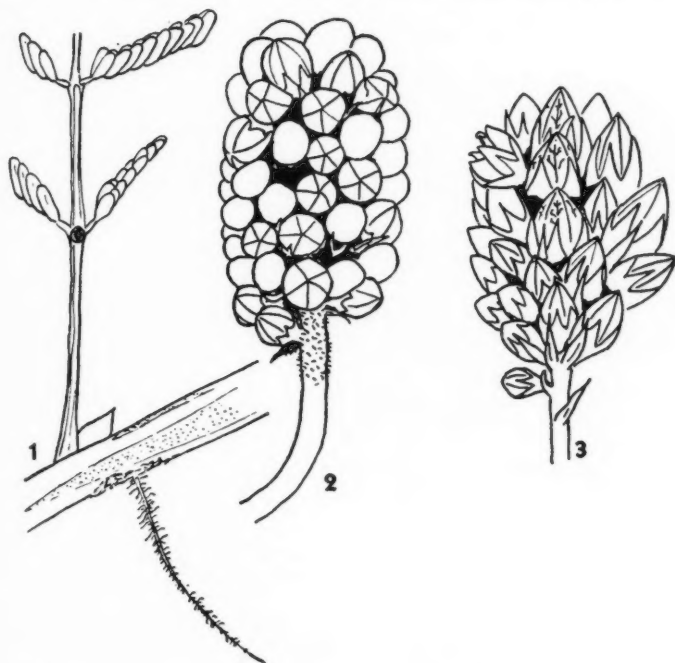
themselves on every side, and required some support, when they were full grown."

One collection from the United States. TEXAS: South of Armstrong in Kenedy Co. "The specimen was growing in shallow water." R. Runyon 1959, Oct. 17, 1938 (US). In addition, specimens have been seen from the West Indies, Mexico, and Central and South America.

2a. *N. LUTEA* (Leavenw.) Benth. Journ. Bot. 4: 356. 1842.

Acacia lutea Leavenw., Amer. Journ. Sci. 7: 61. 1823. (Possible type examined; see discussion below.) *Neptunia tenuis* Benth., Journ. Bot. 4: 355. 1842. Isotypes examined, TEXAS, Drummond 150 of 3rd coll. (NY, US). *Neptunia lutea* var. *tenuis* (Benth.) B. L. Robinson, Proc. Amer. Acad. 33: 332. 1898.

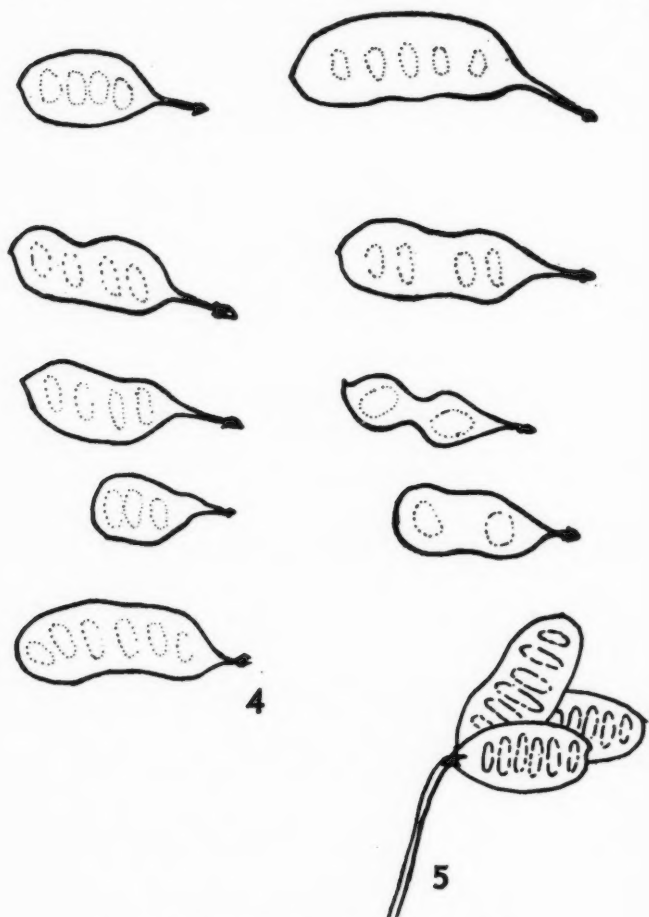
The name *Neptunia virgata* (Bartr.) Trel., Ark. Geol. Surv. Rept. 4: 178, 1888, has been applied to this species. Bartram's reference to "*Mimosa virgata*" was thought by Trelease to be a new combination applicable to *N.*



Figs. 1-3.—1. *N. plena*, portion of leaf showing petiolar gland between the pinnae; 2. *N. lutea*, flower head before anthesis; 3. *N. pubescens* var. *floridana*, flower head before anthesis.

lutea. Bartram, however, was undoubtedly referring to a *Desmanthus*, "sending up nearly erect stems," and not to the prostrate plants of *Neptunia*.

Stems prostrate, up to 2 m. long, widely spreading, pubescent or somewhat glabrate, arising from a tough orange taproot. Stipules broadly lanceolate, pubescent, ciliate, or nearly glabrous; apex rounded, obtuse or sometimes apiculate. Petiole 1-4 cm. long, eglandular, pubescent or nearly glab-



Figs. 4, 5.—4. *N. lutea*, showing variation of pod shapes;
5. *N. Palmeri*, fruiting peduncle.

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ptunia.
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rous. Pinnae 3-6 pairs, 1.5-5 cm. long. Leaflets 8-18 pairs, oblong, oval, or rarely linear, 3-6 mm. long, 1.5-3 mm. wide, ciliate, conspicuously nerved. Flowers 30-50, in dense subcylindric or oblong spikes, sweet-scented or almost odorless, sessile (the lowest rarely pedicelled), all alike and of the same size; bracts subulate, 1-2 mm. long; calyx 1-2 mm. long, 5-lobed, the lobes 0.5-0.8 mm. long; petals 2.5-3 mm. long, separate; stamens about 8 mm. long, all anther-bearing; anthers 2-celled, 0.7 mm. long, 0.5 mm. wide, bearing a sessile or short-stalked gland at apex between the cells. Fruiting peduncles 3-9 cm. long, pubescent or glabrous. Legume 2-6 cm. long, 10-16 mm. wide, broadly oblong to linear-oblong, obtuse, rounded, or apiculate, puberulent, somewhat glabrate in age; stipe of pod elongate, 4-12 mm. long, much exceeding the calyx; seeds 2-6 in each pod, transverse or strongly oblique.

Labels of specimens in the Southern Methodist University Herbarium show the wide variety of habitats of this plant: "fine sand over limestone," "blackland prairies," "post-oak belt, sandy soil," "hillside prairie," "rocky slopes of limestone and marl," "weedy open area in city limits," "gravel pit," "disturbed soil," "plowed strip along fencerow." *N. lutea* var. *tenuis* is evidently a form of this species in which the whole plant has less than the usual amount of pubescence. An attempt was made to distinguish this variety by mapping the two. The result showed complete intermingling of pubescent and glabrate forms. In addition, pubescence was found to vary seasonally, the fall plants being less pubescent than the spring ones. The pod shape varied seasonally also; in the fall a fewer-seeded, irregularly shaped pod formed, whereas in spring the pods tend to have a more uniform shape. Flowering April to October, sparingly in the fall.

The type locality is given by Leavenworth as Green Co., Alabama. Specimens were seen from Alabama, Arkansas, Louisiana, Oklahoma, and Texas. I was unable to locate an indubitable type specimen. Material in the New York Botanical Garden, which should have the type, contained two sheets from the Torrey Herbarium, one of which may possibly include Leavenworth's plant. Both bear printed Torrey and Gray labels, indicating that they were cited in the Flora of North America. They contain no further data. Both sheets are made up of fragments from two species, flowering material of *N. lutea* and fruiting material of *N. pubescens* var. *floridana*. Evidently these were considered the same by Torrey and Gray. Two other specimens, cited by Torrey and Gray, are both *N. lutea*: a collection by Nuttall from "Arkansas and Red River Plain," and a specimen possibly from Oklahoma which bears a note signed by Leavenworth, "of James collection found first by myself in 1820 on the prairies of Alabama." I visited the region of the type locality, Green Co. (which in Leavenworth's time included present Hale Co.), and was able to collect topotype material of *Neptunia lutea*: GREEN CO.: 5 miles southwest of Eutaw, Turner 2224, July 28, 1950 (SMU). HALE CO.: 4.7 miles southwest of Greensboro, Turner 2231, July 29, 1950 (SMU). The plant was found to be frequent on the limestone prairies at the localities mentioned.

2b. *N. lutea* var. *multipinnata* var. nov.

A specie differt pinnis 6-11 jugis.

Leaves up to 9 cm. long, pinnae 6-11 pairs; whole plant conspicuously pubescent; otherwise like the species. TYPE: Weatherford, Parker Co., Texas, S. M. Tracy 8023, June 1, 1902 (US) isotypes NY, US). Known only from the type collection.

3. *N. pubescens* Benth. var. *Lindheimeri* (B. L. Robinson) Turner, comb. nov.

N. Lindheimeri B. L. Robinson, Proc. Amer. Acad. 33: 333, 1898.

TYPE: Prairies about Houston, Harris Co., Texas, *Lindheimer*, June, 1843 (Gray Herbarium; not examined).

Stem prostrate, up to 2 m. long, arising from a tough orange taproot, conspicuously and persistently pubescent. Stipules broadly lanceolate or obliquely cordate, ciliate, pubescent on both surfaces, 2-6 mm. long, 1.0-2.5 mm. wide. Petioles glandless, 1.0-2.8 mm. long. Pinnae 25 pairs, 1.5-4 cm. long. Leaflets 15-30 pairs, 3-5 mm. long, 1.0-1.3 mm. wide, linear, pubescent on the lower surface, especially near the apex, some of the hairs 0.3-0.7 mm. long; strongly veined, apex acute or somewhat apiculate. Flowers in ovoid heads, the lowest flowers smaller than the upper, bearing sterile petaloid stamens; bracts ovate, acuminate, 2-3 mm. long, conspicuous while flowers are in bud; calyx (on fertile flowers) ribbed, 2.5-2.7 mm. long, with 5 subulate lobes 1.0-1.2 mm. long, the lobes conspicuously ciliate (10-30 cilia on each lobe); petals 3 mm. long, separate, pubescent near apex; stamens in upper fertile flowers about 6 mm. long, those of lower flowers

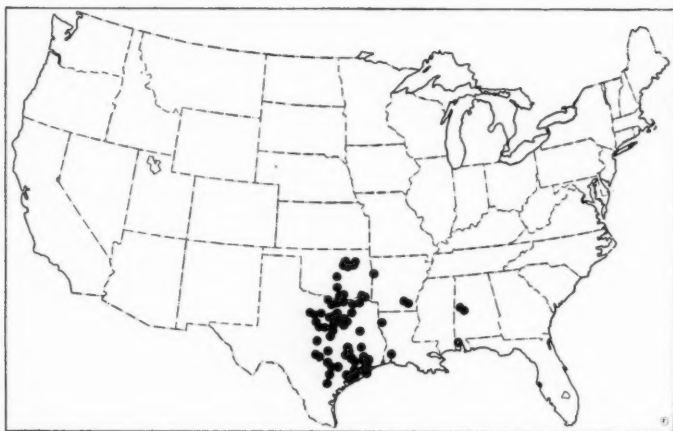


Fig. 6.—Distribution of *N. pubescens* var. *Lindheimeri*

6.7 mm. long, 0.4-0.8 mm. wide, flattened, linear-lanceolate, petaloid, yellow (dying orange); anthers 2-celled, 0.6-0.7 mm. long, 0.5-0.5 mm. wide, bearing a sessile or short-stipitate gland between the cells at apex. Fruiting peduncle 2.5-6 mm. long, pubescent. Legume oblong, 2.5-4 cm. long, 6-9 mm. wide, pubescent while immature, becoming nearly glabrous in age (pubescence persistent near the margins); stipe tapering, 2-4 mm. long; seeds 5-10 in each pod, transverse or strongly oblique.

This variety is restricted to southern Texas where it occurs most abundantly along the coast. Eastward along the Gulf Coast there seems to be a gradual intergradation between *N. pubescens* var. *Lindheimeri* and *N. pubescens* var. *floridana*. The characters given in the key, however, are consistent for the great majority of specimens examined. Comparisons were made with a specimen from the type locality of *N. pubescens* at Lima, Peru (Capt. Wilkes Expedition, 1838-1842, NY). The var. *Lindheimeri* differs from the species in being much more pubescent with longer leaflets and more pinnae. Var. *floridana* is distinguished by being much more glabrous with more pinnae and longer peduncles. Var. *Lindheimeri* flowers from April to November.

3b. *N. pubescens* var. *floridana* (Small) Turner, comb. nov.

N. floridana Small, Bull. Torr. Bot. Club 25: 138. 1898. Small did not designate a particular type, but based his species on "Chapman various collections." Some of Chapman's specimens are mixtures of this plant and *N. lutea*. I have therefore designated as lectotype one sheet, Chapman s. n., no date (NY).

Stems prostrate, widely spreading, slender, glabrate or with scattered

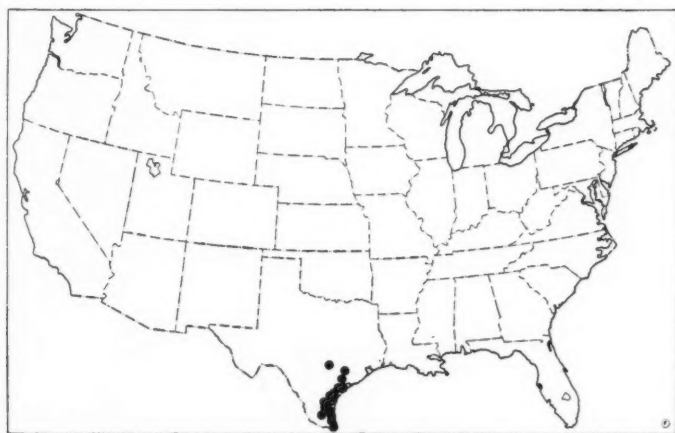


Fig. 7.—Distribution of *N. lutea*

sparse pubescence, arising from a tough orange taproot. Stipules 3-6 mm. long, 1-2 mm. wide, broadly lanceolate or obliquely cordate, glabrous or ciliate. Petioles glandless, 1.0-2.5 mm. long. Pinnae 2-5 pairs, 2-5 cm. long. Leaflets 15-40 pairs, 2-5 mm. long, 1.0-1.4 mm. wide, linear, glabrous or short-ciliate, the cilia 0.1-0.2 mm. long; apex acute or short-apiculate. Flower heads ovoid, about 12 mm. long, 9 mm. wide; upper flowers with anther-bearing stamens, lower smaller, with sterile petaloid stamens; bracts subulate, 1.5-2 mm. long, glabrous or sparsely pubescent; calyx 2.0-2.6 mm. long, 5-lobed, the lobes glabrous or with 1-10 short cilia; petals separate, greenish, 3.0-3.2 mm. long, glabrous; fertile stamens 10, exserted, filiform, 5-7 mm. long; sterile stamens 8-9 mm. long, 0.5-0.8 mm. wide, flattened, petaloid, yellow (drying orange); anthers 2-celled, bearing a sessile or short-stipitate gland at apex between the cells. Fruiting peduncles 6-12 cm. (rarely 4-5 cm.) long. Legume oblong, 1.5-4 cm. long, 6-10 mm. wide, apex rounded or somewhat apiculate, stipe tapering, 2-4 mm. long; seeds 5-11 in each pod, transverse or strongly oblique.

Widely distributed from southern Texas along the Gulf Coast to southern Florida, occasionally found also in Cuba (Oriente) and Porto Rico. Southward from the tip of Florida throughout the West Indies and to Argentina, this variety intergrades with typical *N. pubescens*, which is more pubescent and with shorter peduncles. In Texas the plant occurs commonly on the coastal prairies. In Florida it seems to occur more often in pine woods near the coast. The Florida plant is almost completely glabrous, showing more ciliation westward toward southern Texas where it intergrades with var. *Lindheimeri*. Flowering in the United States from May to October.

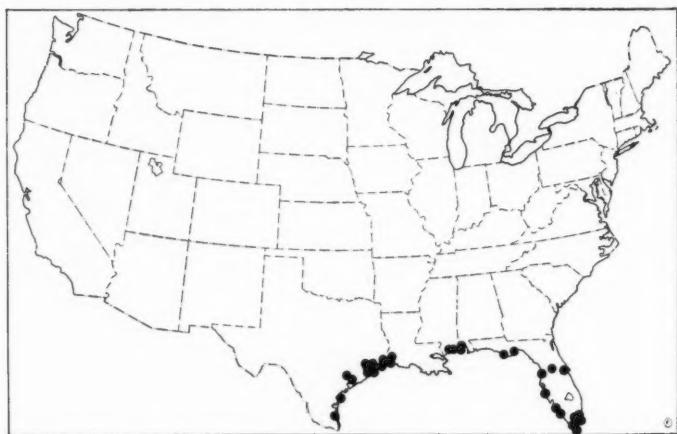


Fig. 8.—Distribution of *N. pubescens* var. *floridana*

4. *N. PALMERI* Britton & Rose, N. Amer. Fl. 23: 182. 1928.

TYPE: Juraz about 100 miles north from Monclavo on the Sabinas River, Coahuila, Mexico, Dr. E. Palmer 300, Sept. 23-24, 1880 (NY; isotypes M, US).

Stems prostrate, up to 1 m. long, several arising from a tough orange taproot, glabrous or with a few scattered hairs. Stipules broadly lanceolate, 3-7 mm. long, 1.5-2.5 mm. wide, glabrous or sparsely ciliate. Petioles glandless, 1.0-2.5 cm. long, glabrous or sparsely pubescent. Pinnae 2-3 (rarely 4) pairs, 2-6 cm. long. Leaflets 15-35 pairs (rarely 10-15), 3-7 mm. long, 1.0-1.4 mm. wide, glabrous or very short-ciliate (the cilia scarcely 0.1 mm. long), apex tapering, acute or rarely obtuse; conspicuously veined. Flowers 15-30 in small ovoid heads about 8-9 mm. long, 4-5 mm. wide before anthesis, the upper flowers with anther-bearing stamens, the lower with sterile petaloid stamens; bracts 1.5-2.1 mm. long, ovate-acute, glabrous or sparsely ciliate; calyx 2.0-2.5 mm. long, 5-lobed, the lobes 0.7-1.0 mm. long, glabrous or with 1-10 cilia on each lobe; petals 2.7-3.2 mm. long, separate, glabrous; anther-bearing stamens about 7 mm. long, filiform; sterile stamens lanceolate, petaloid, 7-8 mm. long, 0.5-0.8 mm. wide, yellow (drying orange); anthers 2-celled, bearing a sessile or short-stipitate gland at apex between the cells. Fruiting peduncles 3.5-7 cm. long, glabrous or sparsely rough-pubescent. Legume 1.8-4 cm. long, 1.0-1.6 cm. wide, glabrous (sparsely pubescent when immature); seeds 5-11 in each pod, transverse or strongly oblique. The pod resembles that of *N. lutea*, except for the shorter stipe; the flowers are like those of *N. pubescens*.

Found from Gonzales to Maverick and Val Verde counties in Texas, and in adjacent Mexico. There is possibly some intergradation between this

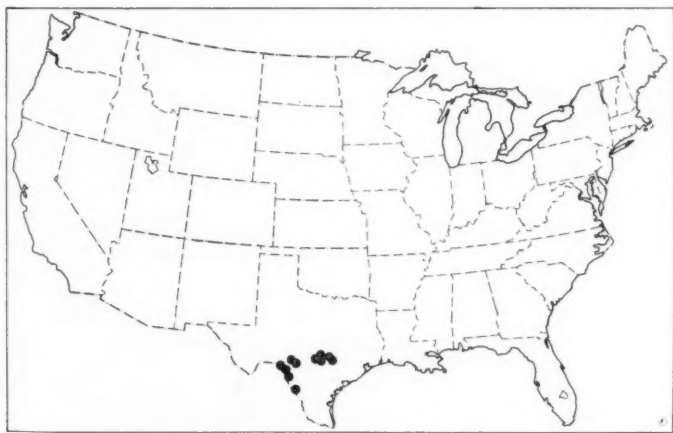


Fig. 9.—Distribution of *N. Palmeri*

species and *N. pubescens* var. *Lindheimeri* in the area of Gonzales and Bexar counties, since the species here seems to be more pubescent than farther south or west. Robinson (1898) referred this plant to *N. pubescens* (typical), of South America. The large pod, intermediate between those of *N. pubescens* and *N. lutea*, separates the species rather conveniently. The plant is peculiar in the genus for its habitat (dry calcareous soils in areas of low rainfall), representing the opposite extreme from the type species of the genus, *N. prostrata*, which is a tropical aquatic plant. Britton and Rose in their brief description of the fragmentary type give the number of pinnae as 2 pairs, which seems constant for the Mexican specimens. In Texas, however, plants are found which have 2 pairs, 2 and 3 pairs, or very rarely 2-4 pairs. Flowering from May to July.

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The American Genera of Malvaceae

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The family Malvaceae offers many problems to the taxonomists. Opinions differ widely as to where to draw the line between species, between genera, and between tribes. Even definition of the family in the order Malvales is a disputed question. For example, the Bombacaceae were regarded by Bentham and Hooker (6 p. 198) as a tribe (or suborder) of the Malvaceae, whereas K. Schumann (73 p. 202; 74 p. 53) treated them as a separate family. Schumann retained Tribe Hibisceae of Bentham and Hooker in the Malvaceae, but Edlin (13 p. 126) transferred this tribe, together with the genus *Kydia*, to the Bombacaceae, as Tribes Hibisceae and Kydiae, respectively.

CLASSIFICATION OF THE FAMILY

Bentham and Hooker, in 1862 (6 pp. 196-199) distinguished 4 tribes of the Malvaceae: 1. Malveae, 2. Ureneae, 3. Hibisceae, and 4. Bombaceae. They classified the genera of Tribe Malveae in 4 subtribes: Malopeae, Eumalveae, Sideae, and Abutilae.

A somewhat different arrangement was adopted by K. Schumann (73 pp. 259-262; 74 pp. 34-47), whose classification was as follows:

Tribe 1. Malopeae. Carpels one above another in 5 "fields" (Feldern) opposite the petals.

Tribe 2. Malveae. Carpels in a single verticil; fruit (except in *Bastardia*) a schizocarp; style-branches of the same number as the carpels. Three subtribes were distinguished in this tribe: 1. Abutilinae, with 2 or more ovules in the carpels. 2. Malvinae, with a solitary, erect or ascending ovule and the style-branches (except in *Malvastrum*) introrsely stigmatic. 3. Sidiinae, with a solitary pendulous ovule, the raphe dorsal and the stigmas (except in *Plagianthus*) apical, capitate. A synopsis of the genera and species of Tribe Malveae as known at that time (1890-1894) was published by E. G. Baker (1-5).

Tribe 3. Ureneae. Carpels in a single verticil; fruit a schizocarp; style-branches double the number of the carpels.

Tribe 4. Hibisceae. Carpels in a single verticil; fruit a loculicidal capsule; style-branches of the same number as the carpels, or the style undivided. Schumann followed Bentham and Hooker in dividing Tribe Hibisceae into 2 series: A. Style-branches long; seeds reniform. B. Style simple and clavate, or divided at apex into short, erect branches; seeds angulate or obovoid.

The reason given by Edlin (13 p. 126) for transferring the whole of Tribe Hibisceae and the genus *Kydia* to the Bombacaceae was that the fruit is either

loculicidally dehiscent or else indehiscent, hence capsular or baccate rather than schizocarpous (septicidally dehiscent). Nevertheless he retained genera *Bastardia* and *Bastardiopsis* in the Family Malvaceae, which he characterized as having "septicidally dehiscent schizocarps," although actually these genera have capsular (incompletely septicidal) fruits. The distinction between loculicidal and septicidal fruits is not easily made, even within certain genera, such as *Pavonia* and *Abutilon*. The present writer, therefore, prefers to keep the Hibisceae and genus *Kydia* in the Malvaceae.

No comprehensive treatment of the family has appeared since Edlin's contribution. Hochreutiner (39 pp. 124, 128-129; 41 pp. 422-424), pointing out the variability of most of the characters upon which the tribes, subtribes, and genera of Malvaceae are based, concluded that a radically different classification of the family should be attempted. He has not offered one, however, and the writer has been unable to discover any satisfactory alternative to the basic concepts of Bentham and Hooker and of Schumann. The latter's classification is adhered to, in the main, in this paper. The only important departures are in Tribe Malveae, where a new subtribe, *Corynabutilinae* and a new genus, *Corynabutilon*, have been distinguished. Also the genus *Malvastrum* and several genera segregated from it (*Malacothamnus*, *Nototriche*, *Sidopsis*, *Tarasa*), as well as *Urocarpidium*, have been transferred from subtribe Malvinae, where Schumann placed *Malvastrum*, to subtribe Abutilinae, notwithstanding the fact that the carpels are normally uniovulate. The genera in question have apical stigmas whereas, in Malvinae the styles are introrsely stigmatic. On the other hand, the erect or ascending position of the ovule excludes these genera from subtribe Sidinae.

Several monographs and revisions of particular genera have appeared and numerous additional genera have been published, since Schumann treated the family in *Die Natürlichen Pflanzenfamilien*. These will be referred to in the Notes on the Genera that follow the key.

The classification of the American genera that is followed in the present paper may be summarized as follows:

Tribe 1, Malopeae. Carpels numerous, in 2 or more superposed verticils. Fruit a schizocarp; carpels uniovulate, the ovule ascending; stigmas apical; involucre none: genus *Palaua*.

Tribe 2, Ureneae. Carpels in one verticil; style-branches twice the number of the carpels, the stigmas apical; fruit a schizocarp. Carpels uniovulate, the ovule ascending; involucre present, except in most species of *Malachra*: genera *Blanchetiastrum*, *Codonchlamys*, *Goethea*, *Limnia*, *Malachra*, *Malvaviscus*, *Pavonia*, *Triplochlamys*, *Urena*.

Tribe 3, Hibisceae. Carpels in one verticil; style-branches of the same number as the carpels or the style undivided; fruit capsular or baccate. Carpels (except in *Kosteletzkya*) pluriiovulate; involucre commonly present: genera *Abelmoschus*, *Cienfuegosia*, *Gossypium*, *Hibiscus*, *Kosteletzkya*, *Montezuma*, *Thespesia*, *Ulbrichia*, *Wercklea*.

Tribe 4, Malveae. Carpels in one verticil; style-branches of the same number as the carpels; fruit (except in *Bastardia* and *Bastardiopsis*) normally a schizocarp (4 subtribes).

Subtribe *Corynabutilinae*. Stigmas decurrent on both sides of the thick, more or less complanate-clavate style-branches; carpels pluriiovulate; involucre none: genera *Corynabutilon* and *Neobaclea*.

Subtribe Malvinae. Stigmas introrsely decurrent on the slender style-branches; carpels uniovulate, the ovule erect or ascending; involucler present or absent: genera *Althaea*, *Callirhoe*, *Lavatera*, *Malva*, *Napaea*, *Sidalcea*.

Subtribe Abutilinae. Stigmas apical or very nearly so; carpels pluriovulate or, if uniovulate, then the ovule erect or ascending except in the few uniovulate species of *Wissadula*: involucler present or absent (nearly always present in the normally uniovulate genera): genera *Abutilon*, *Bakeridesia*, *Gayoides*, *Horsfordia*, *Iliamna*, *Kydia*, *Malacothamnus*, *Malvastrum*, *Modiola*, *Neobrittonia*, *Nototriche*, *Phymosia*, *Pseudabutilon*, *Sidopsis*, *Sphaeralcea*, *Tarasa*, *Urocarpidium*, *Wissadula*.

Subtribe Sidinae. Stigmas apical; carpels uniovulate, the ovule pendulous or resupinate; horizontal; involucler none, except in one section of genus *Sida*: genera *Abutilothamnus*, *Anoda*, *Bastardia*, *Bastardiopsis*, *Briquetia*, *Cristaria*, *Gaya*, *Periptera*, *Robinsonella*, *Sida*, *Tetrasida*.

PURPOSE OF THE KEY AND CHARACTERS USED

The key presented here will, it is hoped, make it fairly easy to identify the genera. Taken with the notes which follow, it constitutes a reasonably comprehensive synopsis of the family as now known to exist in North and South America. Material of several of the genera has not been accessible to the writer and it has been necessary in those cases to depend upon published descriptions. The fruit of one genus, *Blanchetiastrum*, apparently is unknown. As far as possible, however, the characters have been checked by examination of specimens.¹ The key is somewhat artificial and the order in which the genera appear in it does not necessarily indicate their closest relationship. Only species that occur in the Americas were taken into account in formulating the characterizations.

Several of the characters upon which the divisions of the key are based vary within the limits of a genus, so it has been necessary to place a few of the genera in more than one division of the key. The principal "key characters" will now be reviewed briefly, quoting freely from the admirable papers in which Hochreutiner has discussed the morphology, ontogeny, and phylogeny of various structures of the fruit. His *Organes carpiques nouveaux ou méconnus chez les Malvacées* (40) and *Notes sur les genres Cristaria, Bakeridesia, Malvastrum* (41) have been particularly useful.

Involucler.—In most of the genera the involucler (epicalyx, calyculus) is either present or wanting in all of the species, but in *Sphaeralcea* and *Malvastrum*, which usually have an involucler, this structure is normally absent in one or two species; and in *Sida* a few species possess a more or less persistent involucler, although a great majority of the species show no vestige of this organ.

Carpocrater.—This structure, aptly so-designated by Hochreutiner, was described by him in detail (40 pp. 348-357). It was interpreted by this author as resulting from lateral expansions of the bases of the carpels which

¹ The writer is much indebted to the curators and staffs of the herbaria of the following institutions for the privilege of examining herbarium material: California Academy of Sciences, Chicago Natural History Museum, Gray Herbarium of Harvard University, New York Botanical Garden, Smithsonian Institution, University of California.

become fused with the expanded base of the columella or receptacle, forming a cup-like structure embracing the lower part of the fruit. It is composed usually of fibrous tissue and is always free from the more or less foliaceous calyx. Only the genus *Cristaria* possesses a typical and well-developed carpocrater, but Hochreutiner found an approach to this organ in the expanded base of the columella in several genera of Subtribe Malvinae and in *Abutilon*, and a still closer approach in one species of *Sida* (*S. palmata* Cav.), which has knob-like dorsal thickenings of the bases of the carpels.

Stigmas.—The style-branches are introrsely stigmatic in all genera of Tribe Malveae Subtribe Malvinae as restricted by the writer to exclude *Malvastrum*, and are stigmatic at apex and decurrent on both sides of the style-branch in Subtribe Corynabutilinae. In all American members of Subtribes Abutilinae and Sidinae, so far as the writer knows, the stigmas are apical (capitate, discoid, or truncate), except that in *Phymosia*, in most species of *Iliamna*, and in one species of *Sphaeralcea* the truncation is so oblique that the stigma might be considered as very slightly decurrent.

Ovules, number.—In Tribe Malveae, both genera of Subtribe Corynabutilinae and the more typical genera of Subtribe Abutilinae are characterized by having more than one ovule per locule, although Hochreutiner pointed out (39 pp. 127-129; 41 pp. 421-424) that uniovulate carpels occur, normally or occasionally, in certain species of *Abutilon*, *Gayoides*, *Wissadula*, and *Sphaeralcea*. In *Malvastrum* and several allied genera which the writer would transfer to Subtribe Abutilinae, the ovule is almost invariably solitary, as is also the case in all genera of Subtribes Malvinae and Sidinae.

Ovules, position.—In Tribe Malveae, the position of the ovule, whether erect or pendulous, was used by Bentham and Hooker to distinguish their Subtribes Eumalveae and Sideae, and by Schumann to distinguish his Subtribes Malvinae and Sidinae. Hochreutiner (39 pp. 127-129; 41 pp. 423, 424) noted that in the mostly pluriiovulate Subtribe Abutilinae the position of the ovules varies from erect or ascending to pendulous and that all stages between erect and pendulous are encountered in the uniovulate Subtribes Malvinae and Sidinae. The writer believes, however, that the exceptions in the latter two tribes are too few to invalidate the general distinction, and that the genera of Subtribe Sidinae, with a pendulous or resupinate-horizontal ovule, are almost invariably distinguishable by this character from the genera of Subtribe Malvinae and from the uniovulate genera and species of Subtribe Abutilinae, in which the ovule is erect or ascending, except in uniovulate species of *Wissadula*.

Endoglossum.—This term was introduced by Hochreutiner to designate various internal appendages of the dorsal wall of the carpel which more or less completely divide the cavity. The morphology, ontogeny, and probable function of these structures have been discussed by him at considerable length (40 pp. 357-363, 368-376; 41 pp. 422-423). They vary in character from the horizontal septum which divides the cavity into two superposed compartments

in *Modiola* and, less completely, in *Pseudabutilon*, to the peculiar and highly specialized endoglossum of *Gaya*, which appears, in the mature carpel, like a detached layer of the dorsal wall, more or less crescent-shaped and embracing the seed. Hochreutiner has demonstrated, however (40 pp. 357-358) that the initial stages of development of the endoglossum of *Gaya* may be observed even in the ovary. A less highly developed endoglossum, not completely dividing the cavity, is found in many species of *Sphaeralcea* and, according to Hochreutiner, in several species of *Sida*.

Carpel wings.—The genera *Bakeridesia* and *Horsfordia*, and most of the species of *Cristaria*, are characterized by wing-like outgrowths of the carpels. In *Bakeridesia* the wing or pair of wings is dorsal and was considered by Hochreutiner (37 p. 298) to be formed from the concrescent lateral walls of the carpel. In the other genera the wings constitute the accrescent, smooth, dehiscent apical section of the carpel. The first stages in the development of such apical wings are seen in *Sphaeralcea*, *Gaya* etc. (Hochreutiner, 40 pp. 383-386).

Carpel awns and spines.—In most of the genera of Malvaceae the carpels are muticous, mucronate, or shortly rostrate at apex, but in *Pavonia*, Sect. *Typhalaca*, and in *Bastardiopsis*, *Tarasa*, *Urocarpidium*, and certain species of *Sida*, the carpels bear apical or subapical, retrorsely barbed or pilose awns, these often much longer than the body of the carpel. Hochreutiner (40 p. 380) stated that in early stages the awn appears single, but splits into two when the carpel is mature. *Urocarpidium*, however, is an exception to this rule, the awn remaining single at full maturity. In *Briquetia* and *Neobrittonia*, instead of apical awns, the carpels bear dorsal spines, one at the upper angle and two at the basal angles of the of the carpel. *Urena* is unique in the family in having the whole dorsal surface of the carpel beset with glochidiate spines.

Carpel reticulation.—In the genera *Horsfordia*, *Sphaeralcea*, and *Urocarpidium* the indehiscent basal section of the carpel is reticulate with anastomosing fibers, these separated by thin areolas, whereas the dehiscent apical section is smooth. The line of demarkation between the two sections coincides with the apex of the (often deep) ventral sinus. In most of the pluriiovulate species of *Sphaeralcea* the dehiscent apical section is as large as or larger than the reticulate indehiscent section, but in a few uniovulate species the reverse is true. It has been remarked by Hochreutiner (40 pp. 366, 367) that in the latter case we have an approach to the condition in certain species of *Malvastrum* and *Sida* whose carpels, at maturity, split open at the apex, but not enough to release the seed.

Carpel dehiscence.—The fruit, in most of the Malvaceae, is a schizocarp, the mature carpels separating from one another by septicial dehiscence and also separating from the axis or columella, although, in several genera, they may remain attached to the latter, long after maturity, by thread-like branches of the nerve or nerves of the carpel. Septicial dehiscence is found in Tribe

Malopeae and in most genera of the Ureneae and Malveae, although in some species of *Pavonia* (*Asterochlaena*), in *Kydia*, in *Bastardia* and *Bastardiopsis*, in many species of *Abutilon*, and exceptionally in *Sphaeralcea*, the septicidal dehiscence is very tardy or even fails entirely. Loculicidal dehiscence of the mericarps of schizocarpous fruits may or may not occur. Hochreutiner (40 p. 365) contrasted the primarily loculicidal dehiscence in *Abutilon* to the primarily septicidal dehiscence in *Sphaeralcea*.

Tribe Hibisceae, on the other hand, is characterized by the general absence of septicidal dehiscence, the fruits being capsular or baccate and either loculicidal or indehiscent. There is much variation, especially in Tribe Malveae, in the extent of the loculicidal dehiscence. In some of the genera, notably in Subtribe Malvinae, the carpels are achene-like and virtually indehiscent. In many species of *Sida* there is a slight splitting open of the apex of the carpel without formation of an aperture large enough to release the seed. The carpels are completely loculicidal, separating into two valves at maturity, in a few genera of Subtribe Abutilinae. These are the pluriovulate *Phymosia* and *Iliamna*, and the uniovulate *Tarasa*, *Malacothamnus*, *Sidopsis*, and (so far as is known), *Nototriche*. The mechanisms for effecting dehiscence have been described by Hochreutiner (40 pp. 363-371, 383-387; 43 pp. 88-90).

KEY TO THE GENERA

1. Carpels in 2 or more superposed verticils. Annual or perennial herbs; flowers axillary, solitary; involucl (calyculus) none; stigmas capitate; carpels indefinitely numerous, 1-ovulate, indehiscent, separating at maturity from one another and from the columella or receptacle: Tribe Malopeae1. *Palaua*
1. Carpels in a single verticil 2
2. Style-branches and stigmas twice the number of the carpels. Stamen-tube not filamentiferous at the apex, this usually dentate; stigmas capitate or discoid; fruit a schizocarp; carpels normally 5, often indehiscent or tardily dehiscent; ovule solitary, ascending: Tribe Ureneae 3
2. Style-branches and stigmas of the same number as the carpels, or the style unbranched and the stigma entire or nearly so: Tribes Hibisceae and Malveae11
3. Bractlets of the involucl 3 or 4, united below into a long tube. Shrubs or undershrubs 4
3. Bractlets 5 or more, or distinct, or wanting 5
4. Stipules rather broad, colored; peduncles very long, filiform, flexuous; involucl with an elongate-turbinate, 4-angled tube and broad, colored lobes; calyx shorter than the involucl, longer than the oblong petals; stamen-tube shorter than the involucl; herbage lepidote. Mature fruit unknown2. *Blanchetiastrum*
4. Stipules narrow, not colored; peduncles short, not flexuous; involucl long-campanulate, only slightly cleft, somewhat 2-lipped; calyx equaling or somewhat longer than the involucl, much shorter than the linear, red petals; stamen-tube much longer than the involucl; herbage scabrous to velutinous. Plants with the aspect of *Malvaviscus*; corolla tubular or cylindric; carpels (at least in *C. tilifolia*) 3-horned at apex3. *Codonanthus*
5. Involucl-bractlets in 2 series, the outer ones shorter and sometimes spreading or reflexed, or else differing in shape from the inner ones. Trees or shrubs; leaves elongate, lanceolate, lance-elliptic, or oblanceolate; bractlets 14 to 20; stamen-tube usually long-exserted, filamentiferous to the middle or lower; carpels scarcely carinate, acuminate, dehiscent; seeds glabrous4. *Triplachlamys*

5. Involucel-bractlets in one series 6
6. Petals auriculate on one side of the claw; fruit berry-like until full maturity, with a fleshy outer envelope. Plants shrubby or arborescent; flowers solitary in the axils, or in terminal or subterminal clusters; involucl of 5 to 16 narrow bractlets; corolla funnellform, the petals connivent or spreading only at apex; column usually long-exserted; carpels indehiscent, unappended, becoming dry and stony, usually finally separating 5. *Malvastrum*
6. Petals not auriculate; fruit not berry-like or fleshy but the individual carpels (in *Lopimia*) mucilaginous externally when young 7
7. Inflorescence subtended by an involucre of conspicuously veined, foliaceous bracts, these often whitish and scarious toward base; flowers often attached to the bracts; involucl either none and the inner flowers subtended only by narrow stipules; or (in *M. radiata*), each flower subtended by an involucl of numerous filiform bractlets. Plants herbaceous or shrubby, usually hirsute or villous; inflorescence more or less capitate; carpels mucicous, unarmed, indehiscent or ventrally dehiscent toward base 6. *Malachra*
7. Inflorescence not foliaceous-involucrate, or the bracts wholly foliaceous; flowers free from the subtending bracts; involucl always present, the bractlets various 8
8. Cauliflorous shrubs, with many of the flowers borne along the stems on short branchlets from the axils of fallen leaves; involucl-bractlets large and showy, red or red-veined, membranous. Involucl somewhat bladder-like, the bractlets usually 4, distinct, persistent, ovate, or rounded and cordate; carpels incurved toward apex, bidentate on the ventral side 7. *Goethea*
8. Plants not cauliflorous; involucl-bractlets small or narrow, green 9
9. Carpels uniformly armed over the back with glochidiate spines, these rarely wanting; leaf-veins (at least the midvein) bearing on the back a thick-margined open gland near the base. Herbs or shrubs; involucl of 5 partly united bractlets, adnate below to the calyx-tube; carpels trigonous, indehiscent or tardily dehiscent ventrally 8. *Urena*
9. Carpels not uniformly armed with spines, but sometimes mucicate or bearing at apex 1 to 3 retrorsely barbed awns; leaf-veins without glands. Involucl-bractlets distinct, or united at base and with the calyx 10
10. Carpels covered with a thin mucilaginous pellicle, becoming black and shiny when dry, mucicous; calyx very short (much shorter than the involucl), thin, widely expanded in fruit. Large shrubs; flowers very numerous, appearing panicle, the corolla funnellform; bractlets 12 to 22, narrow 9. *Lopimia*
10. Carpels not mucilaginous-coated; calyx at least half as long as the involucl, or of thicker texture, or not becoming widely expanded, or the carpels long-awned. Plants shrubby, suffrutescent, or herbaceous; bractlets 4 to 25 10. *Pavonia*
11. Fruit capsular or baccate, the carpels remaining attached to one another and to the axis; stamen-tube not (or only exceptionally) filamentiferous at the apex, usually dentate or lobed. Involucl usually present but sometimes much reduced; fruit loculicidally dehiscent or indehiscent; locules 5 or fewer: Tribe Hibisceae 12
11. Fruit (except in *Kydia*, *Bastardia*, *Bestardiopsis*, and exceptionally in *Abutilon* and *Sphaeralcea*) a schizocarp, the carpels separating finally from one another and from the axis; stamen-tube filamentiferous at and often also below the apex: Tribe Malveae 20
12. Style-branches becoming more or less divergent, the stigmas more or less capitate or discoid; seeds usually reniform 13
12. Style-branches short and erect, or the style unbranched and clavate; seeds usually angulate or obovoid 16
13. Ovule solitary, ascending; capsule depressed, saliently 5-angled. Plants herbaceous or shrubby; involucl of 5 to 10 narrow bractlets, rarely obsolete 11. *Kosteletzkya*

13. Ovules 2 or more in each locule; capsule not depressed or, if lightly so, then not saliently angled14
14. Bractlets of the involucre 2 or 3, ovate, more or less united into a tubular-campanulate or cupulate involucre, this usually splitting on one side nearly to the base; trees; leaves very large, suborbicular or broader than long, the margin undulate to shallowly dentate. Ovules numerous, amphitropous; capsules bristly, winged or prominently angled, the carpels long-beaked12. *Wercklea*
14. Bractlets more than 3 (rarely none), or narrower, or distinct, or the plant not a tree with leaves as in *Wercklea*15
15. Calyx regularly 5-toothed or 5-lobed, persistent13. *Hibiscus*
15. Calyx spathaceous, irregularly 2- or 3-lobed, deciduous. Plants herbaceous or suffrutescent; bractlets narrow, distinct; calyx adnate at base to the corolla and falling with it; ovules numerous in each locule; capsules usually elongate and pointed, the walls not woody14. *Abelmoschus*
16. Walls of the fruit chartaceous to coriaceous, becoming dry and brittle, the fruit a rather promptly loculicidal capsule. Seeds usually hairy17
16. Walls of the fruit fleshy or leathery, becoming woody and not noticeably brittle, the fruit tardily or irregularly dehiscent, or almost indehiscent. Plants trees or large shrubs18
17. Plants herbaceous or suffrutescent; bractlets of the involucre more than 3, small and narrow, or the involucre wanting; calyx deeply 5-cleft, the oil-glands, when present, in definite longitudinal rows; cotyledons not black-dotted15. *Cienfuegosia*
17. Plants (in the wild) shrubby to arborescent; bractlets 3, persistent and foliaceous to small, subulate, and caducous; calyx dentate to nearly entire, with oil-glands usually scattered but sometimes in rather definite longitudinal rows; cotyledons black-dotted16. *Gossypium*
18. Calyx circumscissile near the base after anthesis; ovary glabrous; corolla rose-colored to crimson within when fresh. Seeds glabrous17. *Montezuma*
18. Calyx persistent, ovary stellate-pubescent or lepidote; corolla yellow to nearly white when fresh19
19. Fruit indehiscent; calyx more or less expanded in fruit; leaves entire or merely undulate-margined; seeds glabrous or pubescent18. *Thespesia*
19. Fruit tardily loculicidal; calyx cup-shaped, partly investing the fruit; leaves 3- to 5-angled or lobed; seeds glabrous19. *Ulibrichia*
20. Stigmas decurrent on the style-branches, the latter filiform to clavate but usually not noticeably expanded at the very apex: Subtribes *Corynabutilinae* and *Malvinae*21
20. Stigmas apical or very nearly so, capitate, discoid, or obliquely truncate, usually distinctly larger than the apices of the style-branches: Subtribes *Abutilinae* and *Sidinae*28
21. Style-branches thick and blunt, more or less complanate-clavate, hairy below; stigmas capping the style-branches and decurrent on both sides of the branch; ovules several in each locule; carpels acuminate to long-aristate, loculicidal as well as finally septicidal. Plants suffrutescent to arborescent; involucre none: Subtribe *Corynabutilinae*22
21. Style-branches slender, pointed, introrsely stigmatic; ovule solitary, ascending; carpels usually reniform and mucous, indehiscent or nearly so: Subtribe *Malvinae*23
22. Calyx-lobes very broad, cordate, pinnately lobulate, appearing winged and spirally twisted in the bud; leaves pinnately lobulate; plant suffruticose20. *Neobactea*
22. Calyx-lobes not very broad, not cordate, entire; leaves palmately (in one species subpinnately) lobed; plants shrubby or arborescent21. *Corynabutilon*
23. Plants dioecious, the pistillate flowers with a non-antheriferous column and 8 or more carpels. A large perennial herb with deeply lobed leaves and numerous

- small white flowers in corymbiform, axillary and terminal panicles; involucl none; stamens borne in an apical whorl22. *Napaea*
23. Plants hermaphrodite or (in *Sidalcea*) sometimes gynodioecious by abortion of the stamens24
24. Filaments all apical or subapical, more or less evidently in 2 whorls, more or less united in phalanges of 2 or more; involucl commonly none. Annual or perennial herbs, rarely suffrutescent; leaves palmately lobed or parted; flowers in terminal racemes or spikes; carpels 5 to 9, beakless or nearly so23. *Sidalcea*
24. Filaments borne at, and usually also considerably below the apex of the stamens, not in 2 whorls or united in phalanges; involucl present (except sometimes in *Callirhoe*). Fruit depressed-discoid25
25. Bractlets of the involucl distinct, 1 to 3, sometimes wanting. Herbs, with lobed or parted leaves26
25. Bractlets more or less united27
26. Carpels usually with an inflexed or incurved beak, this often with its cavity partly separated from the larger, seed-containing cavity by an endoglossum (transverse projection of the dorsal wall); petals broadly truncate, usually erose or fimbriate at apex; tap-root often much thickened24. *Callirhoe*
26. Carpels beakless, the cavity not divided; petals often deeply notched; tap-root not thickened25. *Malva*
27. Involucl with 6 or more (rarely only 5) lobes; receptacle (columella) not enlarged at apex or projecting above the carpels; plants herbaceous26. *Althaea*
27. Involucl with 3 to 6 lobes; receptacle enlarged (conical or discoid) at apex, often projecting above the tips of the carpels; plants herbaceous, shrubby, or arborescent27. *Lavatera*
28. Ovules normally 2 or more in each carpel: Subtribe Abutilinae, in part29
28. Ovule normally solitary: Subtribe Abutilinae, in part, and Subtribe Sidinae40
29. Involucl none30
29. Involucl present36
30. Carpels 2-winged in fruit. Plants shrubby or suffrutescent31
30. Carpels not winged32
31. Carpels winged dorsally, the wings separate to the base or partly united, sinuate-dentate to pectinate on the margin, the carpels not reticulate28. *Bakeridesia*
31. Carpels splitting above into erect or somewhat divergent scarious wings, these entire or nearly so, the (usually smaller) indehiscent basal section of the carpel strongly reticulate29. *Horsfordia*
32. Carpels more or less completely divided into 2 superposed cavities. Herbs or shrubs33
32. Carpels 1-celled, the cavity undivided34
33. Carpels 5 (rarely 3, 4, or 6), 2-celled by horizontal or oblique constriction of the lateral walls (this very slight in *W. contracta*), with no internal projection of the dorsal wall: Section *Euwissadula*30. *Wissadula*
33. Carpels 5 to 11, 2-celled by a horizontal projection of the dorsal wall (endoglossum)31. *Pseudabutilon*
34. Carpels with 2 stout, retrorse, subbasal, dorsal spines. Plant herbaceous; stems hirsute with long hairs; leaves deeply cordate, deeply 3- to 5-lobed; petals mauve; carpels about 9, large, greatly inflated, papery-walled, bristly, finally separating from the axis but long remaining attached thereto by subapical ligaments32. *Neobrittonia*
34. Carpels without dorsal spines35

35. Carpels greatly inflated, rounded and muticous at apex, the walls thin and paper;
plant herbaceous or merely suffrutescent, the stems often weak and vine-like;
flowers relatively small, on slender axillary peduncles. Carpels promptly loculi-
cidal and tardily septicial, normally hirsute with long hairs33. *Gayoides*
35. Carpels not or only moderately inflated, commonly more or less pointed at apex and
mucronate to rostrate or aristate, the walls firm-membranous to coriaceous; plants
herbaceous, shrubby, or arborescent; flowers often large and showy34. *Abutilon*
36. Plants dioecious; fruit a capsule (not septicial); seeds side by side, 2 in each
carpel; bractlets of the involucl 4 to 6, united toward base, persistent. Trees
with large, shallowly lobed leaves; bractlets oblong or spatulate, much longer than
the calyx, accrescent, becoming leathery; style 3-branched35. *Kydia*
36. Plants with perfect flowers; fruit normally a schizocarp; seeds one above the other;
bractlets usually 3, commonly distinct, often calycous37
37. Carpels almost completely septate by a transverse projection of the dorsal wall
(endoglossum), with 1 ovule in each compartment; stamen-tube filamentiferous
at apex. Plants herbaceous; bractlets 3, more or less persistent, often foliaceous;
carpels deeply incised, often bicuspidate or bi-aristate on the dorsal angle, rugose
below, hirsute, septicial and partly loculicidal36. *Modiola*
37. Carpels not septate but the dorsal wall sometimes bearing a palate-like internal fold
(endoglossum) at base of the dehiscent section of the carpel, this projecting a
short way into the cavity; stamen-tube usually filamentiferous below, as well as at
apex. Nectary of 5 segments; carpels often remaining attached to the axis, long
after maturity, by a thread-like branch of the midrib38
38. Carpels apically dehiscent and smooth, basally indehiscent and reticulate, the reticu-
lation rarely obscure; stigmas usually symmetrically capitate or very nearly so.
Herbs, mostly perennial; involucl usually caducous, the 1 to 3 bractlets filiform
to narrowly lanceolate; seeds reniform, usually pubescent37. *Sphaeralcea*
38. Carpels dehiscent to the base on both sutures, not differentiated apically and basally,
not reticulate, the valves separating at full maturity; stigmas mostly obliquely
truncate, often very slightly decurrent39
39. Plants large shrubs or small trees; stamen-tube glabrous; carpels with stellate pubes-
cence only; seeds glabrous or nearly so; involucl persistent or deciduous, the
bractlets narrow or broad38. *Physalis*
39. Plants herbaceous, perennial; stamen-tube hirsute; carpels hispid dorsally with long
simple hairs, also pubescent with short stellate hairs; seeds commonly pubescent;
involucl more or less persistent, the bractlets linear to lanceolate39. *Ilamna*
40. Involucl present. Ovule (except in *Sida*) erect or ascending41
40. Involucl none but (rarely in *Sida*) a false involucl of several narrow bracts borne
on the peduncle shortly below the calyx48
41. Cavity of the carpel more or less completely divided into 2 compartments by a
transverse septum (endoglossum), the lower compartment holding the seed. An-
nual or perennial herbs; bractlets 3, adnate to or borne below the calyx; carpels
dehiscent to about the middle36. *Modiola*
41. Cavity of the carpel not divided but sometimes (in *Sphaeralcea*) with a palate-like
fold of the dorsal wall (endoglossum) at base of the dehiscent section, this pro-
jecting a short way into the cavity42
42. Carpels indehiscent or incompletely dehiscent, the walls usually firm43
42. Carpels completely dehiscent, the valves separating at maturity, the walls thin46
43. Carpels sharply differentiated into a smooth, dehiscent, empty apical section and a
reticulate, indehiscent basal section, the latter containing the seed. Annual or
perennial herbs; bractlets small and narrow, usually caducous44
43. Carpels not sharply differentiated apically and basally, usually without reticulation45
44. Bractlets 1 to 3, rarely none; carpels muticous to cuspidate, dehiscent at apex; plants

- annual to perennial37. *Sphaeralcea*
44. Bractlets 3 to 5; carpels bearing a single very long, slender, flexuous, pilose, apical awn, not dehiscent at apex but splitting along the ventral edge of the upper section; plant annual. Flowers very small, subsessile in secund racemes40. *Urocarpidium*
45. Ovule erect or ascending. Plants annual or perennial, herbaceous to shrubby; carpels incurved-rostrate to muticous, usually more or less rugose, sometimes appendaged externally on the back, the lateral walls firm and persistent to thin and soon disintegrating41. *Malvastrum*
45. Ovule pendulous. Plants perennial, herbaceous; stems decumbent or prostrate; herbage closely stellate-canescens or lepidote; flowers axillary, mostly solitary; involucre present or absent; fruit discoid to hemispheric; carpels muticous or short-beaked, the lateral walls disintegrating and releasing the seed: Section *Pseudomalvastrum*54. *Sida*
46. Carpels biaristate, the awns often longer than the body of the carpel, spreading or reflexed, pilose or plumose, the carpels smooth to reticulate; flowers in secund racemes. Bractlets small and narrow, caducous; petals pink or mauve42. *Tarasa*
46. Carpels muticous, unappendaged, not rugose or reticulate; flowers not in secund racemes47
47. Plants perennial, mostly suffrutescent or suffruticose; flowers in (often dense) axillary clusters, these forming interrupted, more or less leafy, spike-like or paniculate inflorescences; calyx not accrescent; petals white, pink, or rose-purple, much surpassing the calyx43. *Malacothamnus*
47. Plant annual; flowers mostly solitary in the axils; calyx conspicuously angulate and accrescent, thin-membranous; petals yellow, little surpassing the calyx. Plant with aspect of *Sida*44. *Sidopsis*
48. Stipules united with the petiole, forming a sheath; peduncles adnate to the petioles; plants caulescent or nearly so. Small herbs, chiefly high Andean, mostly perennial and with thick caudices, often pulvinate; carpels often beaked, loculicidal (so far as known) to the base or nearly so45. *Nototriche*
48. Stipules and petioles not thus united but the peduncle (in *Sida ciliaris*) often adnate to the petiole of the subtending leaf; plants caulescent49
49. Fruit technically a capsule, the 5 carpels loculicidal to the base but not or incompletely septicidal and not (or very tardily) separating from the axis at maturity. Leaves entire or dentate, cordate; ovule pendulous50
49. Fruit a schizocarp, septicidally dehiscent, the carpels separating from the axis and usually from one another at maturity51
50. Plants herbaceous or shrubby; herbage glandular-pubescent; flowers mostly solitary in the axils; calyx-lobes and the yellow petals spreading in anthesis; capsule depressed-globose; carpels 5 to 8, muticous or cuspidate; seeds rounded-trigonus46. *Bastardia*
50. Plant arborescent; herbage minutely stellate-canescens, not glandular; flowers in ample terminal panicles; calyx-lobes and the white petals reflexed in anthesis; capsule pentagonal, obpyramidal; carpels 5, 2-awned, the awns densely plumose, flexuous, much longer than the body of the carpel; seeds suboval, compressed. Leaves large, broadly ovate, the veins prominent beneath47. *Bastardiopsis*
51. Carpels greatly inflated, much larger than the seed, muticous, the walls thin, papery or membranous52
51. Carpels not greatly inflated54
52. Plants shrubby or arborescent; flowers large and showy, in panicles or lateral clusters, the petals white, pink, or greenish; carpels erect or somewhat divergent. Calyx lobes spreading or reflexed; carpels tardily dehiscent48. *Robinsonella*
52. Plants herbaceous or suffrutescent; flowers relatively small, solitary in the axils, the petals mostly yellow; carpels more or less connivent53

53. Carpel-cavity not divided and without an internal appendage; ligaments (attaching threads) usually wanting or poorly developed 33. *Gayoides*
53. Cavity usually partly divided longitudinally by an outgrowth (endoglossum) originating near the base of the dorsal wall but becoming detached and often finally appearing as if attached to the ventral wall, the endoglossum often pectinate, more or less embracing the seed; ligaments present, 2 or 3 per carpel, holding the carpel attached to the columella until maturity 49. *Gaya*
54. Bases of the carpels dilated and forming, with the basal expansion of the columella, a cup (carpocrater) which supports and partly encloses the fruit, this structure free from the calyx. Plants herbaceous or suffrutescent; petals usually white or pink; fruit flat and depressed or truncate-conical; carpels many, usually with erect or incurved terminal wings, thin-walled, the lateral walls reticulate and persistent, or smooth and evanescent 50. *Cristaria*
54. Bases of the carpels not dilated into a carpocrater. Carpels wingless or (sometimes in *Sida*) the bivalvate apex somewhat wing-like 55
55. Carpels with 2 long dorsal hooks on each side at the basal angles, and a third at the upper angle. Plants herbaceous or suffrutescent; leaves large; flowers in an ample, much-branched, leafless, terminal panicle; petals yellow; carpels usually 9, indehiscent 51. *Brquitia*
55. Carpels without basal hooks, sometimes (in *Anoda*) 1-spurred dorsally 56
56. Carpel-cavity partially divided into 2 superposed compartments by a transverse fold or ring at base of the dehiscent portion. Plants shrubby or suffrutescent; leaves entire or nearly so; carpels 4 or 5, not reticulate basally: Section *Wissada* 30. *Wissadula*
56. Carpel-cavity not divided as above, but an endoglossum (palate-like internal projection of the dorsal wall) sometimes present in *Sphaeralcea* 57
57. Petals adnate to the very short stamen-tube nearly to its middle. Shrub or small tree; leaves large, entire; anthers forming a dense globular mass; styles about 15, very nearly distinct; carpels small, dehiscent dorsally; seeds villous 52. *Abutilothamnus*
57. Petals adnate to the stamen-tube only near its base 58
58. Carpels differentiated into a smooth, ventrally dehiscent apical section and a (usually larger) rugose-reticulate, indehiscent basal section. Plants herbaceous 37. *Sphaeralcea*
58. Carpels not differentiated apically and basally 59
59. Ovule erect or ascending 41. *Malvastrum*
59. Ovule pendulous or resupinate-horizontal 60
60. Calyx unequally 4-lobed; plant a large shrub or small tree; leaves entire, ovate or elliptic; carpels loculicidal nearly to the base, with attaching ligaments. Flowers numerous, in terminal panicles composed of fascicles; calyx cup-shaped, much shorter than the corolla, the lobes not connivent; petals yellow 53. *Tetrasida*
60. Calyx 5-toothed or 5-lobed; plants herbaceous to shrubby; leaves usually toothed or lobed; carpels indehiscent or but slightly or irregularly dehiscent 61
61. Lateral walls of the carpels firm, persistent; seeds without an aril-like envelope. Flowers axillary and solitary, or more or less aggregated in racemes, spikes, or heads; calyx usually angulate, sometimes much-acrescent, the lobes commonly erect or connivent over the fruit; carpels muticous to birostrate or biaristate, often rugose or muricate, indehiscent or slightly dehiscent at apex 54. *Sida*
61. Lateral walls of the carpels fragile, soon disappearing or becoming lacerate; seeds usually more or less enveloped by an arilliform, often reticulate endocarp, this sometimes closely adherent to the seed-coat. Fruit discoid to nearly hemispheric, depressed, the carpels incurved and with a dorsal angle, umbo, or spur 62

62. Petals spreading, broadly obovate, yellow or purple; stamen-tube relatively stout, shorter than the petals; style-branches abruptly dilated into a capitate or discoid stigma55. *Anoda*
62. Petals erect, spatulate to obovate, red; stamen-tube very slender, much longer than the petals; style-branches subclavate toward apex, the stigmas scarcely larger than the style-tip, obliquely truncate56. *Peripera*

NOTES ON THE GENERA

The genera, with the exception of *Sida*, are arranged in the order in which they first appear in the key and are numbered the same. The year of publication of each genus is inserted after the name of the author.

Tribe 1. MALOPEAE

1. *Palaua* Cav., 1785.—The only American genus of this small tribe, distinguished from all other American Malvaceae in having the carpels superposed vertically. Some 18 species have been described, of which 9 were included by E. Ulbrich in his key to the species, published in 1908 (83 pp. 106, 107). With the possible exception of one species reported from Mexico (*P. tomentosa* Hochr.) the genus is known only in Peru and Chile. The plants are annual or perennial herbs with habit of *Cristaria*, undivided or variously divided leaves, axillary, long-stalked flowers, and no involucl.

Tribe 2. URENEAE

2. *Blanchetiastrum* Hassler, 1910.—A monotypic genus, so far as is known, represented only by *B. goetheoides* Hassler, of Brazil. It is distinguished from most members of Tribe Ureneae by the large, foliaceous stipules, gamophyllous 4-lobed involucl with an elongate-turbinate tube, and filiform, flexuous, axillary peduncles longer than the leaves. Hassler (30 p. 28) considered it to be most nearly related to *Goethea*, but in the latter genus the involucl is of 4 to 6 distinct or very nearly distinct bractlets, and the axillary or extra-axillary peduncles are much shorter than the leaves. The fruit of *Blanchetiastrum* apparently is unknown.

3. *Codonochlamys* Ulbr., 1915.—A genus of two, more or less woody, species of central and southern Brazil, distinguished, like *Blanchetiastrum*, from most of the Ureneae by a gametophyllous involucl, but differing from *Blanchetiastrum* in the narrow stipules, short peduncles, elongate stamen-tube, etc. (See Ulbrich, 85 pp. 329-333). In the last character, and in the shape and color of the corolla, these plants resemble *Malvaviscus*, but the petals, presumably, are not auriculate and the fruit is very different.

4. *Triplochlamys* Ulbr., 1915.—This genus comprises the 5 species, all natives of Brazil, which Gürke (25 pp. 475, 479, 480) included in his Section *Tricalycaris* of the genus *Pavonia*. The genus differs from *Pavonia* chiefly in having the 14 to 20 bractlets of the involucl arranged in two series, the inner ones longer or of different shape and texture. Ulbrich (85 pp. 333-335) gave, as other characters distinguishing *Triplochlamys*, the large, thick, persistent stipules, the non-carinate or nearly non-carinate carpels dehiscent

from the base dorsally, and the large, elongate-reniform, glabrous seeds. The plants are shrubs or arborescent, with large lanceolate or oblanceolate leaves, and carpels, so far as known, unarmed.

5. *Malvaviscus* Adans., 1763.—An exclusively American genus, ranging from the southern United States and the West Indies to Brazil and Peru. Some 60 species have been published but Schery, in his monograph of the genus (72) recognized only 3 species, relegating most of the published names to synonymy under *M. arboreus* Cav. and 10 varieties thereof. The character usually depended upon to distinguish this genus from *Pavonia* and other Ureneae is the baccate fruit, the carpels being enclosed in a fleshy envelope until full maturity. As Schery pointed out (72 p. 189), this character is not apparent in old fruit and the auriculate petals are the best distinction of the genus, which is characterized also by a usually bright red, more or less funnel-form corolla and a very slender, usually long-exserted stamen-column.

6. *Malachra* L., 1767.—There are probably not more than 9 species of *Malachra* (Gürke 26 pp. 330-361) although some 30 names are listed in *Index Kewensis*. The genus is common to the warmer regions of both the Eastern and Western Hemispheres, but these weedy plants may have been introduced into the Old World. Some of the species are extremely variable and difficult to define, although Gürke (26) and Hochreutiner (39, pp. 144-149) have sought to bring order out of the confusion. The outstanding characteristic of the genus is the fact that the more or less capitate inflorescences are subtended by large foliaceous bracts, to which the flowers are often attached. An involucl is usually wanting except in *M. radiata* L., the sole representative of Gürke's Section *Pavonioides*, which has each flower subtended by subulate-filiform bractlets. The plants are perennial herbs, or somewhat shrubby.

7. *Goethea* Nees, 1821.—A genus of 3 or 4 shrubby species, confined to eastern Brazil. The genus is distinguished by cauliflory and by the large and showy somewhat bladder-like, more or less colored, persistent involucl of 4 to 6 bractlets, these distinct or very nearly so. The large stipules are appressed to the stem. The carpels are unarmed.

8. *Urena* L., 1753.—Although some 65 names of species are listed in *Index Kewensis*, the number of valid species is only 6, according to Gürke (26 pp. 361-385). These are widely distributed in the warmer regions of both hemispheres. The genus differs from all other American Malvaceae in having the carpels uniformly armed on the back with glochidiate spines, these rarely wanting. Also characteristic is the large, thick-margined open gland near the base of the midvein on the dorsal surface of the leaf. The plants are large herbs or somewhat woody, and of weedy habit.

9. *Lopimia* Mart., 1823.—This genus was revived by Standley (78 pp. 114, 115) with two species, *L. malacophylla* Mart., the type species, of southern Mexico, Cuba, Colombia, and Brazil, and *L. dasypetala* (Turcz.)

Standl., which ranges from Costa Rica to Venezuela. The two species are similar, being large, velvety-pubescent shrubs, with very large ovate leaves and numerous large *Malvaviscus*-like flowers. *L. malacophylla* is also remarkable for the very numerous (15-24) narrow involucre-bractlets, but in *L. dasypetala* the bractlets are fewer (about 12). These plants are quite different in appearance from any species of *Pavonia* known to the writer and this fact, in conjunction with the peculiarities of the calyx and carpels, seems to warrant maintenance of the genus *Lopimia*.

10. *Pavonia* Cav., 1786. (*Malache* B. Vog., *Typhalea* Neck., *Lebretonia* Schrank, *Anotea* Kunth (?), *Asterochlaena* Garcke, *Pseudopavonia* Hassler, *Peltaea* (Presl) Standl.).—This, one of the largest genera of the family and almost wholly tropical or subtropical, comprises some 230 names, listed in *Index Kewensis*, that have not been reduced formally to synonymy. In the absence of a comprehensive monograph of the genus, it is impossible to estimate more closely its actual size. Of these 230 "species," approximately one-third are found in the Old World. The rest range through the Americas from the southern United States and the West Indies to Argentina and Bolivia (Chile?), the greatest concentration of species being in Brazil and Paraguay. Most of the American species are herbaceous or suffrutescent, but some are shrubby. Excluding the 7 species that are here regarded as belonging to other genera (*Lopimia*, *Triplochlamys*) the remaining American species fall into 3 sections, as follows:

Carpels 3-ristate, the awns retrorsely barbed Sect. *Typhalea*

Carpels not aristate, either muticous, mucronate, gibbous, or shortly rostrate.

Bractlets of the involucre (except usually in *P. speciosa*) stipe-like, more or less rigid, abruptly expanded at apex into a thickish, often reflexed, peltate or sub-peltate bladelet Sect. *Peltaea*

Bractlets not so-expanded Sect. *E. pavonia*

Section 1. *Typhalea* Gürke (*Typhalea* Neck., as a genus).—Gürke (25 pp. 475, 476) included 15 species in this section and several others have been described from tropical America. There is also at least one species in the Old World tropics. The section seems well-defined, in the main, although *P. paniculata* Cav., of section *Eupavonia*, with normally muticous carpels, is described by Fawcett and Rendle (14 p. 131) as having them with occasionally "a very weak short spine at apex." There is no general correlation of the awned carpels with other characters, although several species of Sect. *Typhalea* are characterized by elongate leaves and flowers more or less congested at the ends of the stems and branches. One member of this section, *P. spinifex* (L.) Cav. is the first species enumerated by Cavanilles (9 p. 132, t. 45) under his description of the genus, but *P. paniculata* Cav. has been proposed by M. L. Green as the lectotype of genus *Pavonia* (7 p. 145).

Section 2. *Peltaea* (Presl) Gürke (*Peltaea* Standl., as a genus, *Peltobractea* Rusby, as a genus).—This section comprises the 3 species enumerated by Gürke (25 p. 477) and also *P. Preslii* Standl. (*P. ovata* (Presl) Standl.

non *P. ovata* Spreng.). The peculiar involucre of this species and of *P. sessiliflora* H.B.K. and *P. Riedelii* Gürke (*Peltobractea nigrobacteata* Rusby) would seem to entitle the group to recognition as a genus, but in *P. speciosa* H.B.K. only subsp. *polymorpha* (St. Hil.) Gürke has stipe-like bractlets abruptly expanded into a subpeltate bladelet. In most forms of this species, although they are otherwise very similar to subsp. *polymorpha*, the bractlets vary from linear to narrowly spatulate, as in many species of Section *Eupavonia*.

Section 3. *Eupavonia* Gürke.—This section includes by far the largest number of the American species of *Pavonia*. They differ greatly in many characters but no basis has been found for the distinction of additional sections, unless we recognize Sections *Malvaviscoides* and *Goetheoides* of Gürke (25 pp. 475, 479) each with 4 species. These are all shrubs or undershrubs, and all are natives of Brazil. The species of section *Malvaviscoides* are somewhat *Malvaviscus*-like in foliage and shape of the corolla. The stamen-tube is long-exserted in *P. malvaviscoides* St. Hil. and *P. erythrolemma* Gürke, barely so in *P. montana* Garcke. The carpels of *P. montana* are rather promptly septicidal and also loculicidal, splitting into halves at maturity. Section *Goetheoides*, so far as may be judged by the scanty material available to the writer, is a somewhat heterogeneous assemblage of species, of which *P. longepedunculata* Gürke is remarkable for the very long peduncles of the solitary axillary flowers. Gürke's Section *Tricalycaris* is treated here as a separate genus, *Triplochlamys*, Ulbr. Two other segregate "genera" remain to be considered.

Kunth published in 1846 a genus *Anotea*. This was revived in 1915 by Ulbrich (84), who included in it besides *A. chlorantha* Kunth, the type species, also *A. flavida* (DC.) Ulbr. (*Malvaviscus* ? *flavidus* DC.), both presumably from Mexico. Schery (72 p. 231) conjectured that these plants belong to *Pavonia* but since the fruits are unknown, their identity remains doubtful.

Garcke (18) based a genus, *Asterochlaena*, on a Peruvian species (*A. cuspidata* Garcke) which seems never to have been transferred to *Pavonia*. Garcke stated that it differs from all other Malvaceae in having the fruit both septicidally and loculicidally dehiscent, a much too sweeping statement. In 1909 Hassler (29 p. 74) published, as a genus, *Pseudopavonia*, based upon *P. tenax* Hassler of Paraguay, which he described as having the fruit loculicidally but not septicidally dehiscent. Discovering soon afterward that the fruit is finally septicidal, he transferred it to *Asterochlaena*, to which he referred 5 other species of *Pavonia*, in 3 sections defined by the relative earliness of the loculicidal and the septicidal dehiscence (29 pp. 381-383; 30 pp. 113-118). These relations are scarcely determinable in herbarium specimens, and Hochreutiner (45 p. 314) considered *Asterochlaena* unworthy of recognition as a genus. According to him, regular loculicidal dehiscence occurs, early or late, in all species of *Pavonia* except those in which the dorsal nerve

of the carpel is obsolete, although, in species with thick-walled carpels like *P. spinifex*, the loculicidal splitting is postponed until germination begins.

Tribe 3. HIBISCEAE

11. *Kosteletzkya* Presl, 1836.—A well-characterized genus, comprising some 45 names of species not formally reduced to synonymy, divided equally between the Old World and the New. The greatest concentration of the species occurs in Mexico and in tropical Africa. The prominently 5-angled, depressed fruit and the solitary ovule distinguish this genus from others of Tribe Hibisceae. The leaves are usually more or less hastate.

12. *Wercklea* Pittier & Standl., 1916.—This genus was based upon *W. insignis* Pitt. & Standl. (78 p. 112), to which another species *W. lutea* Rolfe, was added later. Both are small or medium-sized trees of the forests of Costa Rica, with large, purplish or yellowish, hollyhock-like flowers (Paul C. Standley, personal communication). The genus is related to *Hibiscus*, being distinguished therefrom by having an involucl of only 2 or 3 large united bractlets. According to Pittier and Standley (ibid.) the ovules are amphitropous in *Wercklea*, and they mention also, as distinctive, "the winged capsule, oblong anthers, and comparatively few stamens."

13. *Hibiscus* L., 1753.—A very large genus, although of the approximately 550 names of species listed in *Index Kewensis* and not formally reduced to synonymy, probably only a fraction represents valid species. The genus is widely distributed in the warmer parts of the world, with more than two-thirds of the listed species confined to the eastern hemisphere. The species are most numerous in tropical Africa and the genus is remarkably well-developed in the Island of Madagascar. Most of the species have large and showy flowers and many are cultivated as ornamentals. The plants are herbaceous, shrubby, or arborescent.

A revision of *Hibiscus* was published in 1900 by Hochreutiner (34) who recognized 197 species. He divided the genus into 12 sections, 5 of which include American species. Of these, Sect. 9, *Abelmoschus*, is here treated as a distinct genus. Skovsted (76 pp. 21, 22) concluded, from the results of hybridization experiments, that *Abelmoschus* and Hochreutiner's Sect. 5, *Furcaria*, DC., are valid genera. The latter, typified by *H. furcellatus* Desr., which ranges from southern Florida and the West Indies to southern South America, is characterized by having the bractlets of the involucl often bifurcate at apex. Other sections sometimes regarded as distinct genera are: Sect. 2, *Azanza*, Garcke (genus *Pariti*, Adans., *Paritium*, St. Hil.) represented in tropical America by *H. tiliaceus* L., a large shrub or small tree with woody capsules and carpels incompletely divided longitudinally by a septum that tends to split into two membranes at maturity; and Sect. 8, *Trionum* (genus *Trionum* Medic.) with a large bladder-like fruiting calyx. This section is typified by the Old World *H. Trionum* L., adventive here and there in America, with which Hochreutiner associated several native American species with a less accrescent calyx.

14. *Abelmoschus* Medic., 1787.—A genus of approximately 15 species, distinguished from *Hibiscus* by the irregularly 2- or 3-lobed spathaceous calyx, this deciduous before the fruit matures. The plants are herbaceous or at most suffrutescent. The species are all natives of the Old World but *A. esculentus* (L.) Moench, the well-known garden vegetable okra or gumbo, and *A. moschatus* Moench (*Hibiscus Abelmoschus* L.) are cultivated extensively in the warmer parts of America and occasionally are found growing spontaneously. The genus was recognized by K. Schumann (74 pp. 49-50). Hochreutner treated *Abelmoschus* as Sect. 9 of *Hibiscus* in his revision of that genus in 1900, but in 1924 (43 pp. 83-85) concluded that it is a valid genus. He dismissed the character of a spathaceous calyx as being shared by certain Old World species of *Hibiscus*, and minimized the importance of the caducity of this organ, but found, as a good generic character, the basal cohesion of the calyx with the tube formed by concrescence of the petals and stamens, so that when the latter becomes detached the calyx necessarily falls off with it.

15. *Cienfuegosia* Cav., 1787.—This genus has been treated by Hochreutner (35 pp. 54-59) and more recently by J. B. Hutchinson (47 pp. 125-131). The latter recognized only 6 American species, with an approximately equal number in Africa. Australian species that have been referred to *Cienfuegosia* probably belong to other genera (*Alyogyne*, Alef., *Notoxylinon*, Lewton, and *Gossypium*, L.). In her treatment of the Argentinian species, Rodrigo (63a, 65) included a seventh American species, *C. hispida* R. E. Fries, which resembles *C. argentina* Gürke in the absence of an involucre. The American species are herbaceous or suffrutescent, and range from southern Texas, southern Florida, and the West Indies to Argentina and Peru.

16. *Gossypium* L., 1753. (*Ingenhouzia* Sessé & Moc., *Thurberia* A. Gray, *Erioxylum* Rose & Standl., *Sclera* Ulbr.).—Approximately 100 names of species, not formally reduced to synonymy, are listed in *Index Kewensis*, of which more than half are ascribed to North and South America. The most recent taxonomic treatment, however, by J. B. Hutchinson (48) recognizes only 20 valid species, which are classified as follows:

1. Wild species without true lint hairs, $n = 13$, so far as is known (15 species).
2. Cultivated species with lint hairs, $n = 13$ (2 species).
3. Cultivated species with lint hairs $n = 26$ (3 species).

Group 2 comprises the cultivated cottons of Old World origin, and group 3 those of the New World. With groups 2 and 3 are associated many wild or semi-wild forms that have been described as species, but possessing lint hairs and therefore, presumably, relics of former cultivation. The truly wild species of Group 1 are widely distributed in tropical and subtropical regions of both hemispheres, in arid habitats remote from cultivated cotton, and with ranges seldom overlapping. Most of them are very distinct, morphologically, from any of the cultivated cotton plants, with usually much smaller involucre-bractlets etc. Nine of these species (or 10 if *G. Davidsonii* Kellogg is main-

tained as a species) are endemics of the western side of North and South America, and adjacent islands.

17. *Montezuma* Sessé & Moç., 1824. (*Maga* Urban).—A monotypic genus, represented by *M. speciosissima* Sessé & Moç., (*Thespesia grandiflora* DC., *M. grandiflora* (DC.) Urb.), known only from Puerto Rico. The early circumscription of the calyx distinguishes this plant from *Thespesia* and other allied genera. It is a tree, up to 15 meters high with large, handsome flowers.

18. *Thespesia* Soland., 1807.—As here understood, there are 2 American species of *Thespesia*, *T. populnea* (L.) Soland., the type of the genus, and *T. cubensis* (Britt. & Wils.) J. B. Hutchinson (*Maga cubensis* Britt. & Wils., *Montezuma cubensis* Urb., *Atkinsia cubensis* Howard). The former is a widely distributed strand plant in the tropics of both hemispheres, whereas *T. cubensis* is known only from Cuba. It is the type of genus *Atkinsia* Howard (46 p. 97) but comparison of Howard's descriptions of *Thespesia populnea* (ibid. p. 94) and *Atkinsia cubensis*, indicates that the differences are such as would be considered of scarcely more than specific magnitude in many genera of Malvaceae. They may be summarized as follows:

In *Atkinsia cubensis*, flowers in short terminal leafless spikes; calyx truncate, with 5 linear-subulate teeth or variously lobed (ruptured by the expanding bud); petals 3 cm. long, much shorter than the stamen-column; ovary 3- to 5-celled; ovules 1 to 3 per locule; seeds glabrous. In *Thespesia populnea*, flowers solitary, axillary; calyx truncate or minutely 5-dentate; petals 4 to 7 cm. long, longer than the stamen-column; ovary 5-celled; ovules 4 or 5 per locule; seeds pubescent.

J. B. Hutchinson (47 pp. 134-138) in his revision of *Thespesia* included *Montezuma* and *Ulbrichia* in that genus.

19. *Ulbrichia* Urban, 1924. (*Armouria* Lewton).—A genus known only from the small island of Beata, off the southern coast of Hispaniola. The plant is a shrub or small tree, with showy, white or whitish flowers. The only known species is *U. beatensis* Urb. (*Armouria beata* Lewton, *Thespesia beata* J. B. Hutchinson). It has been described fully by Urban (88 p. 7), Lewton (56), and Howard (46). The fact that the capsule is loculicidal, although tardily so, is the main justification for separating this genus from *Thespesia*.

Tribe 4. MALVEAE, Subtribe CORYNABUTILINAE

20. *Neobaclea* Hochr., 1929.—A remarkable genus, monotypic so far as known. It differs from all other American Malvaceae in the pinnately lobulate and spirally imbricate calyx-lobes, these resembling the foliage leaves. The flowers are large for the size of the plant and the petals are rose-pink, according to Krapovickas (54). The genus was based by Hochreutiner (44) on *N. spirostegia* Hochr., which is undoubtedly the same as *Sida crispifolia* Cav. (10 t. 419), as was pointed out by Krapovickas (ibid.), who published the combination *N. crispifolia* (Cav.) Krapov. It is suggestive that the next

plate in Cavanilles' *Icones* (t. 420) illustrates *Sida vitifolia* Cav., the type species of *Corynabutilon*. Cavanilles' somewhat diagrammatic figures show great similarity in the shape of the style branches of *S. crispifolia* and *S. vitifolia*. The fruit of *Neobaclea*, as described and illustrated by Krapovickas (ibid.) is much as in *Corynabutilon*. *Neobaclea crispifolia* is known certainly only from the Government of Santa Cruz, in southern Argentina.

21. *Corynabutilon* (K. Schum.) Kearney, 1949.—The genus is based upon *Abutilon* Sect. *Corynabutilon* K. Schum. (73 p. 369), in which Schumann included 4 species, all Chilean. To these E. G. Baker (4 p. 336) added *Abutilon viride* Phil. and *A. Garcke* E. G. Baker, the latter based upon *Sida acerifolia* Garcke, non Lag., also from Chile. Hochreutiner (44) remarked that this peculiar group could perhaps be separated advantageously from *Abutilon*, and he recognized its affinity to his genus *Neobaclea*.

The thick more or less flattened and clavate style-branches, capped by the usually dark-colored stigma which is decurrent on both sides of the branch sometimes for half or more of the length of the latter, are excellent diagnostic characters. They are so different from the slender introrsely stigmatic style-branches of Subtribe Malvinae that it has seemed expedient to recognize an additional subtribe, *Corynabutilinae*, of Tribe Malveae comprising *Corynabutilon* and the nearly related genus *Neobaclea* (52). In the paper cited were published the combinations *C. vitifolium* (Cav.) Kearney, *C. ceratocarpum* (Hook. & Arn.) Kearney, *C. Ochsenii* (Phil.) Kearney, and *C. bicolor* (Phil.) Kearney.

The plants resemble *Abutilon* in most respects, but in that genus the stigmas are apical and capitate or nearly so. The flowers are large, and range in petal color from white to purple. The carpels are very like those of *Abutilon* and are both loculicidal and (tardily) septicidal. In *C. vitifolium* and *C. ceratocarpum* they long remain attached to the columella by a thread-like branch of the dorsal nerve. According to Victor Reiter (personal communication) efforts to hybridize *C. vitifolium* with *Abutilon megapotamicum* St. Hil. & Naud. were unsuccessful.

A Mexican species (*Abutilon mochisense* Hochr.) was referred to Section *Corynabutilon* by Hochreutiner (42 p. 448), who stated that it has the style-branches truncate (not capitate) at apex. Examination of the type shows, however, that the very small stigmas are capitate or very nearly so and not at all decurrent on the slender style-branches. There seems to be no reason to regard this plant as other than a species of *Abutilon*.

Tribe 4 MALVEAE, Subtribe MALVINAE

22. *Napaea* L., 1753.—The sole species of this genus, *N. dioica* L., is the only plant of the family indigenous to the Western Hemisphere that is strictly dioecious. It is confined to the east-central United States. The plant rather strikingly resembles *Sida hermaphrodita* (L.) Rusby, which has nearly the same geographic distribution, but has perfect flowers and apical stigmas. *Napaea dioica* is a large perennial herb, 2 or 3 meters high, with large pal-

mately cleft leaves and an ample corymbose-paniculate inflorescence of small white flowers.

23. *Sidalcea* A. Gray, 1849.—This genus is probably exclusively North American. Roush, in her monograph of the genus (68) recognized 20 species, the great majority confined to the Pacific Coast States, with 2 or 3 species in the Rocky Mountain region. The least typical species is *S. malachroides* (Hook. & Arn.) A. Gray, the type of Greene's genus *Hesperalcea*, characterized by semi-dioecious flowers and close approximation of the two whorls of stamens. Turczaninoff (82 p. 566) published, as *Sidalcea*, 3 species, not since identified, from Chile and Peru but these probably belong to other genera. His *S. triloba* may well be *Corynabutilon vitifolium* (Cav.) Kearney.

24. *Callirhoë* Nutt., 1821.—An exclusively North American genus of about 13 species, principally of the Mississippi Valley and the Plains region east of the Rocky Mountains, with 2 species known only from northeastern Mexico. The genus is a rather artificial one, as was pointed out by Schumann (74 pp. 40, 41), the presence of an endoglossum in the carpels being inconstant and this character appearing also, according to Schumann, in certain species of *Althaea*. Nevertheless, since the most nearly related genera, *Malva* and *Althaea*, are limited to the Eastern Hemisphere (excepting species introduced into the Americas), and since *Callirhoë* is a rather well-defined group in respect to habit and habitat, it may be justifiable to maintain it as a genus.

25. *Malva* L., 1753.—A genus of 25 or 30 species, all natives of the Old World, although many American species of other genera were first described as species of *Malva*. Some 8 Eurasian species (true *Malva*) are more or less naturalized in North and South America.

26. *Althaea* L., 1753.—Some 25 species have been described, all natives of the Old World. Marsh-mallow (*A. officinalis* L.) is sparingly naturalized in the eastern United States and hollyhock (*A. rosea* Cav.) is found occasionally in America as an escape from gardens.

27. *Lavatera* L., 1753.—This genus comprises approximately 20 species, most of which are natives of the Old World, but 4 more or less shrubby species are found on islands off the coast of California and Baja California. There can be no reasonable doubt that the latter are truly indigenous, as was maintained by Parish (59) and Jepson (49 p. 484). A herbaceous species, *L. cretica* L., is extensively naturalized in California, from the Mediterranean region.

Tribe 4 MALVEAE, Subtribe ABUTILINAE

28. *Bakeridesia* Hochr., 1913.—The type species is the Mexican *B. Galeotitii* (E. G. Baker) Hochr. The genus was subsequently expanded by Hochreutiner (41 pp. 418-421) to include another Mexican species, *B. notolophium* (A. Gray) Hochr. and 2 Brazilian species, *B. senilis* (K. Schum.) Hochr.

and *B. rufivela* Hochr. All of these were previously referred to *Abutilon* and these shrubby plants are very like *Abutilon* in habit, appearance, and flowers, but differ in the dorsally 2-winged carpels. Hochreutiner (ibid.) established two sections of the genus, *Monopteron*, with the wings partly united, and *Dipteron* with the wings distinct to the base, the latter section including only *B. senilis*.

29. *Horsfordia* A. Gray, 1887.—Three species of small shrubs, limited to the southwestern United States and northwestern Mexico, constitute the genus *Horsfordia*. The differentiation of the carpels into a reticulate, indehiscent basal section and a larger dehiscent apical section, much as in *Sphaeracea*, sufficiently distinguishes *Horsfordia* from the allied genera *Abutilon* and *Bakeridesia*. In *Horsfordia* the "wings" are terminal and represent merely the accrescent halves of the dehiscent part of the carpel, whereas, in *Bakeridesia*, they were interpreted by Hochreutiner as being outgrowths of the more or less concrescent lateral walls.

30. *Wissadula* Medic., 1787.—A monograph of this genus was published by R. E. Fries in 1908 (16 pp. 1-95). The type of the genus is *W. zeylandica* Medic. (*W. periplocifolia* var. *typica* R. E. Fries), presumably from Ceylon, where it may have been introduced (ibid. p. 22), the genus being predominantly American. Fries stated, however, that *W. amplissima* (L.) R. E. Fries apparently is indigenous in tropical Africa. He recognized 32 species, in addition to 5 species of doubtful affinity. Some 7 species, all American, have been published subsequently. The range of the genus in America is from southern Texas and the West Indies to Argentina.

The 2 sections of the genus established by K. Schumann (75 pp. 236, 237) were recognized by Fries. These are Sect. *Wissada* (Griseb.) K. Schum., with uniovulate carpels, and Sect. *Euwissadula* K. Schum., with 3-ovulate carpels. Fries assigned 2 American species (*W. divergens* (Benth.) Benth. & Hook. and *W. Faydenii* R. E. Fries) to Sect. *Wissada*, and all the other species to Sect. *Euwissadula*.

Hochreutiner (39 pp. 107-112) pointed out the difficulty of separating *Wissadula* from *Abutilon*, on the one hand, and *Sida*, on the other, but concluded that the genus is a "natural" one and should be maintained as a matter of convenience. He stated, however, that in the final analysis it can be distinguished only by the transverse fold of the carpels, a character only slightly developed in *W. contracta* (Link) R. E. Fries and *W. disperma* Hochr., and nearly obsolete in section *Wissada* because of the atrophy of the upper cell of the carpel.

31. *Pseudabutilon* R. E. Fries, 1908.—Fries (16 pp. 96-108) established and monographed the genus *Pseudabutilon*, comprising 6 species previously referred to *Wissadula*, and 3 new species. Six additional species have been published since this monograph appeared, making the total number 15. The genus is exclusively American, ranging from southern Texas and the West Indies to Argentina. Apparently no type species was designated by Fries,

but *P. spicatum* (H.B.K.) R. E. Fries is the first species described in his monograph. The genus is distinguished from *Abutilon* by the partitioned carpels and from *Wissadula* by the fact that in *Pseudabutilon* the two cavities are separated by an endoglossum, a membranous, tongue-like projection of the dorsal wall, rather than by constriction of the lateral walls so as to produce a horizontal fold, as in *Wissadula*. Fries (ibid. pp. 96-97) distinguished 2 subgenera of *Pseudabutilon*, Subgenus *Wissadulastrum* (K. Schum.) R. E. Fries with stellate-turbinate, 5-merous fruits, and carpels with the 2 upper seeds collateral and the lower seed solitary; and Subgenus *Abutilastrum* (E. G. Baker) R. E. Fries, with short-cylindric, 6- to 11-merous fruits and the seeds all in one vertical series.

Hochreutiner (39 pp. 116-121) at first accepted *Pseudabutilon* as a valid genus, remarking that the genus *Gaya* is based upon a similar carpellary appendage, and he pointed out similarities in carpel-structure between *Pseudabutilon* and *Modiola*. He proposed a new subgenus, *Allosidastrum*, having discoid, 8- or 9-merous fruits with the internal projection of the dorsal wall of the carpels nearly apical and not dividing the carpels into two compartments. To this subgenus he referred 2 new species, *P. Smithii* Hochr. and *P. Langlassei* Hochr. In a later paper (41 pp. 422, 423) this author minimized the importance of the endoglossum as a generic character and seemed to question the tenability of *Pseudabutilon* as a genus, although he reached no final conclusion.

32. *Neobrittonia* Hochr., 1905.—A monotypic genus, of which the type is *N. acerifolia* (Lag.) Hochr. of southern Mexico and central America. As described by Hochreutiner (36) it is distinguished from all other genera related to *Abutilon* by having the carpels armed in the center of the lower angle with two long, strong, divergent spines, so arranged as to "rep-rl" the calyx. As expressed by Standley (79 p. 748) "carpels each with 2 retrorse spines below."

33. *Gayoides* (A. Gray) Small, 1903. (*Pseudobastardia* Hassler).—This genus was based upon *G. crispum* (L.) Small (*Abutilon crispum* Sweet), which ranges from the southern United States and the West Indies to Argentina. Hassler (28), who discarded Small's name *Gayoides* for insufficient reasons and substituted the name *Pseudobastardia*, recognized 3 species: *P. crispa* (L.) Hassler, *P. tiubae* (K. Schum.) Hassler, and *P. nemoralis* (A. Juss.) Hassler. The Brazilian *Abutilon tiubae* K. Schum. is perhaps specifically distinct from *Gayoides crispum*, having glandular hairs on the herbage and larger flowers. *P. nemoralis* was distinguished from the other two species of *Pseudobastardia* as having 1-ovulate carpels, but specimens of *Gayoides crispum* from Peru were reported by Svenson (81 p. 463) as having 1-ovulate carpels.

Hassler (ibid.) was surely in error in denying septicidal dehiscence of the carpels of *G. crispum*. They are septicidal, although tardily so. The fruits are remarkably similar to those of *Gaya*, but the carpels are not appendaged within and have an undivided cavity. According to Schumann (74 p. 38)

and Hassler (28 p. 209) the carpels long remain attached to the axis by ligaments, but apparently this is by no means always the case.

An older name than *Gayoides*, *Beloere* Shuttlew., was published by Asa Gray (20 p. 21) in a footnote under *Abutilon crispum*, but, as there seems to be uncertainty about what plant Shuttleworth had in mind as the type, it is inadvisable to revive the name *Beloere*.

34. *Abutilon* Adans., 1763.—A very large genus, widely distributed in the warmer part of both the Eastern and the Western Hemisphere. There are perhaps 125 species in North and South America, in addition to 2 or 3 probably introduced from the Old World, and excluding species that have been transferred to the segregate genera *Corynabutilon*, *Bakeridesia*, *Neobrittonia*, and *Gayoides*.

Although, as would be expected in so large a genus, there is much diversity in habit, foliage, flowers, and fruit, there appears to be little justification for recognizing additional segregate genera. *Abutilon* may be regarded as the most generalized, and phylogenetically perhaps the most primitive of the group of genera of Subtribe Abutilinae characterized by normally pluriovulate carpels and the absence of an involucre. A classification of this genus (Section *Cephalabutilon* K. Schum.) was given by Schumann (75 pp. 235, 236).

There is much variation in *Abutilon* in the dehiscence of the carpels. In all of the species these are loculicidal and in some they are rather early septicidal. In many species, however, dehiscence through the septum is tardy, or possibly does not take place at all. Hochreutiner (40 pp. 364, 365) stated that in the majority of species of *Abutilon* the two halves of the carpel separate completely and the half-carpels fall as individual lamellae. Also that if the half-carpels remain attached it is not the two halves of the same carpel, but the halves of two adjacent carpels that form the pair. It would seem that a comprehensive study of the modes of dehiscence in this genus would be an interesting field of investigation. Contrasting *Abutilon* with *Sphaeralcea*, Hochreutiner (ibid.) concluded that in *Abutilon* the dehiscence is primarily loculicidal and sometimes also septicidal, whereas in *Sphaeralcea* it is septicidal and only partially loculicidal.

35. *Kydia* Roxb., 1814.—A genus of 3 species of dioecious trees of tropical Asia, one of which, *K. calycina* Roxb. (*K. brasiliensis* Barbosa Rodriguez) is sparingly naturalized in the woods around Rio de Janeiro.

36. *Modiola* Moench, 1794.—(*Modiolastrum* K. Schum.). A genus of herbaceous plants, natives of America, although *M. caroliniana* (L.) G. Don is now widely distributed, as a weed, in the warmer parts of the world. *Modiolastrum* was proposed as a genus by Schumann (73 p. 276), although distinguished from *Modiola* only in having 1-ovulate carpels; but, as Hochreutiner pointed out (39 p. 128), this character should not be too much stressed in the Abutilinae. Thus, in *Sphaeralcea*, although most of the species are pluriovulate, a few are normally and others occasionally 1-ovulate. Hochreutiner (39 pp. 121-125) reduced *Modiolastrum* to synonymy and recognized only

two species of *Modiola*, *M. caroliniana* and *M. geranioides* (Hook.) Walp. The relatively large-flowered *M. lateritia* (Hook.) K. Schum. is probably also a distinct species²

37. *Sphaeralcea* St. Hil., 1824.—This genus is here restricted to what the present author (50) formerly treated as *Sphaeralcea* Subgenus *Eusphaeralcea*, characterized by having the basal section of the carpel indehiscent and reticulate³ the apical section dehiscent and smooth, with a (usually deep) notch between the 2 sections, capitate stigmas, and an involucl of narrow bractlets, these commonly deciduous soon after anthesis. The species are all herbaceous or at most suffrutescent, and are mostly perennial. The carpels are prevailingly pluriovulate, but in 10 species normally, and in several others occasionally, the carpels are uniovulate. The genera *Phymosia*, Desv. (*Meliphlea*, Zucc.) and *Iliamna*, Greene are treated here as valid genera, the carpels being dehiscent to the base and not differentiated apically and basally. Cytologically, also, these genera may be distinguished, the haploid chromosome number being 5 or a multiple thereof in *Sphaeralcea*,⁴ 17 in *Phymosia*, and 33 in at least one species of *Iliamna*, as was discovered by Webster (89).

The stigma-character is of less importance than was supposed, formerly. It is true that most species of *Sphaeralcea* have small, capitate, symmetric or very nearly symmetric stigmas and that the 3 species of *Phymosia* and all but one species of *Iliamna* have obliquely truncate and even slightly decurrent stigmas. But in *Sphaeralcea caespitosa* Jones, with rather thick style-branches, the relatively large stigmas are obliquely truncate, and in *Iliamna longisepala* (Torr.) Wiggins the stigmas are capitate and very nearly symmetric.

As here restricted, *Sphaeralcea* comprises 28 species in North America and a smaller number, including the type species *S. cisplatina* St. Hil., in southern South America. The half-dozen or so South African species that have been referred to *Sphaeralcea* (and to *Sphaeroma*, Harv.) may not be congeneric, but no mature fruiting specimens have been available to the writer and the published descriptions are vague as to the characters of the carpels. In a specimen from South Africa of *S. elegans* (Cav.) G. Don the immature carpels show no basal reticulation and are completely dehiscent ventrally and almost completely so dorsally, probably splitting into valves at full maturity. This is indicated also in Cavanilles' illustration of *Malva elegans* (9 t. 16). The relationship therefore seems closer to *Phymosia* than to *Sphaeralcea*. Another South African species, *S. pannosa* Bolus, has obliquely truncate rather than symmetrically capitate stigmas and somewhat resembles *Phymosia abutiloides*

² According to Krapovickas (54b), the basic number of chromosomes is 9 in *Modiola caroliniana*, 5 in the three species which he recognized as constituting the weak genus *Modiolastrum*.

³ *Sphaeralcea Endlichii* Ulbr. of northeastern Mexico, is somewhat anomalous in having the carpels almost completely dehiscent and often only very faintly reticulate at base, but it is otherwise much more like *Sphaeralcea* than *Iliamna* or *Phymosia* (50, pp. 99, 100).

⁴ The number is 5 or 10 in the South American species, as reported by Krapovickas (54a) in his recent revision of the genus in South America.

also in its foliage and flowers, but it has a very different involucl. The broad, deeply crenate persistent bractlets are united at base and this species would therefore belong to *Sphaeroma* as distinguished from *Sphaeralcea* by Harvey (27 pp. 165, 166).

38. *Phymosia* Desv., 1825.—The type species is *P. abutiloides* (L.) Desv., of the Bahamas and Haiti. The writer would include in *Phymosia* also the genus *Melipilea* Zucc., the type of which, *M. vitifolia* Zucc., was identified by Standley (79 p. 767) with *Malva rosea* DC. (*Sphaeralcea rosea* Standl.) of southern Mexico and Guatemala. This and another Mexican species, *Sphaeralcea umbellata* (Cav.) G. Don, have been transferred to *Phymosia* as *P. rosea* (DC.) Kearney and *P. umbellata* (Cav.) Kearney (52). All of these are large shrubs or small trees with palmately lobed leaves and showy flowers. They differ from *Sphaeralcea* in having completely dehiscent, non-reticulate, comparatively large and thin-walled carpels (50 pl. 1), and also in the inflorescence. In *Phymosia* the relatively few flowers are borne in loose, subumbellate cymes terminating the stems and branches, whereas in *Sphaeralcea* the more or less elongate inflorescence is usually narrowly thyrsoid, sometimes open-paniculate or subracemose. *Phymosia* differs from *Iliamna* in the characters given in the key, in the type of inflorescence, and apparently also in the chromosome number, n being 17 in *P. rosea* and *P. abutiloides* (89). The latter is unlike the 2 Mexican species in its smaller, deciduous involucl and smaller flowers with mauve instead of rose-red petals. The involucl is gamophyllous in *P. rosea*, whereas in *P. abutiloides* and *P. umbellata* the bractlets are distinct.

It is probable that *Sphaeralcea crenulata* Brandeg., *S. floribunda* (Schlecht.) Walp., *S. nutans* Scheidw., and *S. Schenckii* Ulbr. also belong to *Phymosia*, but the information at hand does not permit a definite conclusion. All of these species were described from Mexican or Central American material.

39. *Iliamna* Greene, 1906.—This genus was merged in *Phymosia* by Rydberg (70 p. 60) but was revived in 1936 in a revision by Wiggins (90) who recognized 7 species, all of temperate North America. They differ from *Sphaeralcea* and agree with *Phymosia* in their completely dehiscent, non-reticulate carpels, and tendency to have obliquely truncate stigmas, but are very different from *Phymosia* in habit, *Sphaeralcea*-like inflorescence, and geographical distribution, as well as in the characters given in the key. They differ also in chromosome number, if *Iliamna rivularis* (Dougl.) Greene, with $n = 33$ according to Webber (89 p. 319) is typical in this respect. *I. longisepala* (Torr.) Wiggins is unlike the other species in having capitate, very nearly symmetric stigmas.

40. *Urocarpidium* Ulbr., 1916.—A monotypic genus, so far as is definitely known, based upon *U. albiflorum* Ulbr., of Peru.⁵ In addition to the

⁵ *Malvastrum arequipense* Johnst., type from near Arequipa, Peru, may prove to be a second species of *Urocarpidium*, but mature fruit has not been available.

characters given in the key, Ulbrich (86 pp. 63-66) mentioned that the corolla and stamen-tube are so closely connate as to fall as a unit, and that the filaments are borne at the summit of the tube. The styles, stigmas, and ovule were described as similar to those of *Malvastrum*. The genus is unique in that the awn remains single, even when the carpel is fully mature. The latter does not dehisce at the very apex, but only along the ventral suture of the non-reticulate apical section.

41. *Malvastrum* A. Gray, 1849.—This is the most difficult genus of Tribe Malveae to define satisfactorily, having the solitary, erect or ascending ovule of Subtribe Malvinae and the capitate stigmas of Subtribe Sidinae, but being clearly affiliated with Subtribe Abutilinae through the uniovulate species of *Sphaeralcea*. It is very probably of polyphyletic origin.

Malvastrum was, from the first, a heterogeneous assemblage. Of the 8 species listed by Gray under his original description of the genus (19 pp. 21, 22), the first 3 have been transferred to *Sphaeralcea*, the fourth is a *Malacothamnus*, and the last (*M. angustum*) is the type of the genus *Sidopsis*. This leaves a residue of 3 species, *M. Wrightii* A. Gray (now referred to *M. aurantiacum* (Scheele) Walp.), *M. carpinifolium* A. Gray (now referred to *M. coromandelianum* (L.) Garcke), and *M. spicatum* (L.) A. Gray, one of which should be chosen as the lectotype of the genus *Malvastrum* (51).

Some reduction of the heterogeneity is attained if the genus is restricted to species with indehiscent or only slightly dehiscent carpels, as in the last 3 species mentioned above. But even with the removal of *Tarasa*, *Malacothamnus*, *Sidopsis*, and *Nototriche*, all of which have completely dehiscent carpels, the last genus being further distinguished by the absence of an involucre and by the adnation of the peduncles and stipules to the petioles, there remain a large number of South American and a few North American species that differ markedly in habit, foliage, flower-color etc. from the proposed lectotype. Provisionally, a great majority of the American species may be disposed in 4 sections, as follows:

A. *Eumalvastrum*. A group of herbaceous or shrubby species with dentate, serrate, or shallowly lobed leaves, flowers mostly few or solitary in the leaf-axils, and mostly yellow corollas, probably all indigenous to the warmer parts of America, although one of them is now widely distributively as a weed in the Old World tropics. This group would include, in addition to the 3 residual species of Gray's original list, *M. scoparium* (L'Hér.) A. Gray, *M. scabrum* (Cav.) A. Gray, *M. bicuspidatum* (S. Wats.) Rose, etc.

B. *Peruviana*. Herbaceous, chiefly annual, South American species with deeply lobed or variously dissected leaves, flowers in more or less secund racemes, and mostly mauve or purple corollas. *M. peruvianum* (L.) A. Gray is typical of this group, which is mainly, perhaps exclusively, South American, although the Mexican *M. jacens* S. Wats. may belong here.

C. *Eremalche*. Greene (24 p. 208) proposed this name, as a genus, for 3 small desert annuals of the southwestern United States, characterized by long-

pedicelled flowers and whitish, mauve, or purple corollas. These are *M. exile* A. Gray, *M. rotundifolium* A. Gray, and *M. Parryi* Greene, with a fourth species *Eremalche kernensis* C. B. Wolf, described subsequently. They are characterized by nearly orbicular, muticous, *Malva*-like carpels, bordered by a cushion-like radially rugose overlap of the dorsal wall. The carpels are not regularly dehiscent but the thin lateral walls disintegrate at maturity, releasing the seed. Jepson (49 pp. 496, 497) included these species in *Sphaeralcea*, with which they have no close affinity. It is possible that certain species of southern South America, of which the mature fruit has not been seen by the writer, are to be associated with *Eremalche*.

D. *Acaules*. This section comprises numerous high Andean, acaulescent or nearly acaulescent species with a thick woody caudex, the flowers large in proportion to the size of the plant, and the corolla commonly white or purple (yellow in 2 or 3 species). These plants rather strikingly resemble the genus *Nototriche*, but possess an involucler, flowers borne in the axils of the basal leaves, and carpels, so far as is known, indehiscent. This section was monographed by A. W. Hill (32) who recognized 18 species, and several have been published subsequently. The group gives an impression of homogeneity, but Hill (32 p. 216) questioned this and stated that it is a "possibly not very natural group, since they [the species] probably represent the high alpine forms of this large genus and may perhaps be more closely related to some caulescent forms—living or extinct—than they are to each other." Hill also pointed out (32 p. 217) that although the section *Acaules* has much the same geographic distribution as the genus *Nototriche* the habitat preferences of the two groups are different.

M. humile (Gill.) A. Gray, of Chile, is not a *Malvastrum* as the genus is here defined, having the muticous carpels completely dehiscent and splitting into halves, when ripe. Yet this species is so different in habit of growth and other characters that it cannot be associated with any of the genera *Tarasa*, *Malacothamnus*, or *Sidopsis*. Hill (32 p. 217) excluded it from *Malvastrum* Section *Acaules*, although stating that "it has assumed a somewhat similar habit of growth."

Two species of southern Brazil, Uruguay, and Argentina, *M. decipiens* (St. Hil.) K. Schum. and *M. nudum* K. Schum., are exceptional in this genus in lacking an involucler. *M. nudum*, if represented by a collection from Uruguay (Herter No. 88898), probably should be transferred to *Sphaeralcea*, having the carpels differentiated into a smooth, dehiscent, apical section and a reticulate, indehiscent basal section, thus resembling the carpels of certain uniovulate species of *Sphaeralcea*.⁶

M. Wilczekii Hochr. of Argentina, described by Hochreutiner, (40 p. 378; 41 pp. 424-427) as possessing an endoglossum and with an unusually

⁶ Krapovickas (54a p. 216) transferred *M. decipiens* to *Sphaeralcea* as *S. decipiens* (St. Hil. & Naud.) Krapov. and doubted that *M. nudum* is specifically distinct from *M. decipiens*. He also (ibid. p. 193) reduced *Malvastrum Wilczekii* Hochr. to synonymy under *Sphaeralcea mendocina* Phil.

well-developed dehiscent apical section of the carpels, was made the basis by Hochreutiner (41 p. 421) of *Malvastrum* subgenus *Pseudabutilastrum* Hochr.

The South African species, of which 15 were described by Harvey (27 pp. 159-164) and 25 were mentioned by E. P. Phillips (62 p. 403) seem to be true members of the genus *Malvastrum*. They are mostly shrubby or suffrutescent plants, with prevailing red or purple corollas. In *M. capense* (Cav.) Garcke and *M. asperum* (Jacq.) Garcke the carpels rather strikingly resemble those of section *Eremalche*. According to Hochreutiner (39 p. 128) the South African *M. virgatum* (Cav.) Gray & Harv. occasionally has 2-seeded carpels.

42. *Tarasa* Phil., 1891.—A small genus, established by Philippi, (60 p. 10) with *T. Rahmeri* Phil. of southern Peru and northern Chile as the type. This species has the plumose awns much longer than the body of the carpel. Philippi described later (61 p. 321) a second species, *Tarassa* (sic) *Alberti* Phil. as having awns of about the same length as the body. The writer (52) has included in this genus also *T. plumosa* (Presl) Kearney (*Malvastrum plumosum* A. Gray) and *T. Mandoni* (E. G. Baker) Kearney (*Sphaeralcea Mandoni* E. G. Baker). There are probably several other species in southern South America.

43. *Malacothamnus* Greene, 1906.—The fourth species enumerated by Gray (19 p. 21) when he published the genus *Malvastrum* was *M. Fremontii* Torr., which belongs to a group of mostly suffrutescent or suffruticose plants, consimilar in habit, appearance, foliage, flowers, and fruit. So far as is definitely known, the genus is limited to California and northern Baja California. It differs from *Malvastrum* in the completely dehiscent muticous, thin-walled carpels (50 Pl. 2, A, B). Greene (24) proposed the appropriate name *Malacothamnus* for this genus, in which he included 9 species. Eastwood (12a) enumerated 26 species, but Jepson (49 pp. 497-501), under *Sphaeralcea*, a wholly different genus, recognized only 8 species (Nos. 4 to 11 of *Sphaeralcea*) many of the published names having been reduced by him to synonymy, or to varietal rank. Chromosome number has been determined by Webber (89 p. 320) for 6 species, and in all of these $n = 17$ ($n = 5$ or 5^* in *Sphaeralcea*).⁷

44. *Sidopsis* Rydberg, 1932.—This monotypic genus was based by Rydberg (71 p. 541) upon *Sida hispida* Ell. (sic), and *Malvastrum angustum* A. Gray was given as a synonym. Fernald (Rhodora 41: 435, 436) pointed out that Pursh, not Elliott, was the author of *Sida hispida*, so the type species should be designated *Sidopsis hispida* (Pursh) Rydb. emend. Kearney (53). The completely dehiscent carpels (50 Pl. 2, C, D) resemble those of *Malacothamnus*, but the plant is otherwise very different, superficially resembling some of the annual species of *Sida*. It is found in Tennessee, Iowa, Missouri, and Kansas, and has been reported from Alabama.

⁷ The genus has been revised recently by Kearney (53a), who distinguished 21 species.

45. *Nototriche* Turcz., 1863.—This genus of Turczaninoff was revived in 1906 by A. W. Hill (31) for a group of remarkable plants of the high Andes of South America which most previous authors (Gray, E. G. Baker etc.) had referred to *Malvastrum*. Gray (21 pp. 151, 152) however, had distinguished this group as *Malvastra Phyllanthophora*. In his revision of the genus Hill (33) recognized 62 species, and some 30 species have been published subsequently or transferred from other genera. Most of these plants are perennial, with a thick caudex surmounted by a rosette of usually hairy leaves, and they are often aggregated in cushion-like masses, as in the umbelliferous genus *Azorella*. A few species, however, are annual. One species (*N. Staffordiae* Burt & Hill) is remarkable in having trifid calyx-lobes. Although these plants resemble superficially species of the *Acaules* section of *Malvastrum*, *Nototriche* is "distinguished especially by the adnation of the peduncles and stipules to the petioles and by the absence of the involucre bracts or epicalyx" (Hill 33 p. 201).

Tribe 4 MALVEAE—Subtribe SIDINAE

46. *Bastardia* H.B.K., 1822.—A wholly American genus comprising about 8 species, ranging from the West Indies and Mexico to South America, almost exclusively within the tropics. The plants are herbs or small shrubs, remarkable in the Sidinae in the fact that the fruit is technically a capsule. It is composed of 5 to 8, mucous to aristate, thin-walled carpels that open loculicidally but do not separate septically, and the fruit remains attached to the axis as a whole, long after maturity. The herbage is glandular-pubescent and is reported to be ill-scented. The flowers are small, with commonly yellow petals, and the ovules are pendulous.

47. *Bastardiopsis* (K. Schum.) Hassler, 1910.—A monotypic genus of southern Brazil and Paraguay, based by Hassler (30 pp. 40-42) upon *Sida densiflora* Hook. & Arn., which Schumann (73 p. 280) had treated as the sole representative of his section *Bastardiopsis* of the genus *Sida*. It agrees with *Bastardia* in having fruit that is technically a capsule, being dehiscent loculicidally but not septically. Otherwise however, the plant is very unlike any species of *Bastardia*, as is indicated by the characters given in the key.

48. *Robinsonella* Rose & Baker, 1897: (*Rebsamenia*, Conzatti).—A group of Mexican and Central American shrubs and small trees, very handsome in flower, of which 7 species were recognized by Roush in her synopsis of the genus (69). The identity of *Rebsamenia arborea* Conzatti with *Robinsonella* (probably with *R. cordata* Rose & Baker, the type species of *Robinsonella*) was brought to the writer's attention by Paul C. Standley (personal communication).

49. *Gaya* H. B. K., 1822.—Some 20 species, apparently confined to the American tropics, constitute the genus *Gaya*. The 2 or 3 species described from New Zealand probably are not congeneric. The range of the genus is from Mexico and the West Indies to Argentina and Bolivia. The fruits superficially resemble those of *Gayoides crispum*, but the latter is without the

longitudinal endoglossum that usually more or less divides the cavity of the carpel in *Gaya*.⁸ Hochreutiner (40 pp. 357, 358) described this peculiar structure as follows (translated):

"In the mature fruit of nearly all the species it appears as a kind of second dorsal wall, crescent-shaped, reinforced by strong nerves. This wall completely surrounds and retains the seed while the mericarps, membranous and larger than the seed, dehisce along the dorsal median nerve. Kunth and Schumann erroneously interpreted the origin of this organ as detached from the wall of the mature carpel, but it is visible even at the moment of fecundation—although then forming only a simple keel.—If the adult endoglossum appears as if inserted on the ventral wall of the carpel, it is because the carpel grows chiefly in the middle, the region where the endoglossum occurs thus being crowded toward the base and even toward the axial (ventral) face of the cavity." Hochreutiner discussed the function of this organ at considerable length (40, pp. 371-376, with illustrations). Regarding the attaching ligaments he wrote (translated): "At the moment of septicial dehiscence of the fruit, the several carpels, swelling and becoming dry, become detached from the axis and hang around it, retained by two filaments or suspensors which are prolongations of two singular nerves, more or less parallel to the median nerve and which are a part of each commissural nerve."

50. *Cristaria* Cav., 1799. (*Lecanophora* Speg., *Plarodrigoa* Looser).—A genus of annual or perennial herbs, confined to Chile, Peru and southern Argentina, of which 41 species were enumerated by E. G. Baker (3 pp. 75-78; 5 pp. 36, 37). Some 17 species have been published since, or transferred from other genera.

From allied genera *Cristaria* is usually distinguished by the apical wings of the carpels, but in a few species the wings are greatly reduced or even obsolete. The species in question were comprised in the genus *Lecanophora* of Spegazzini (77 pp. 211-213), which was limited by Rodrigo (63) to 4 species of southern Argentina with exalate carpels. For these Looser (57) unjustifiably substituted a new generic name, *Plarodrigoa*.

In *Cristaria* the wings appear to be analogous to those of *Horsfordia* in Subtribe Abutilinae, representing the accrescent, dehiscent, apical section of the carpel. Hochreutiner (41 p. 409) considered the wings to be of secondary importance and wrote (translated): "We propose therefore to consider primarily the presence of a carpocrater as the most important character of the genus, admitting that the wings borne by the mericarps are subject to reduction or even—in exceptional cases—to complete disappearance." The structure and function of the remarkable organ for which the term "carpocrater" was coined by Hochreutiner was discussed by him in another paper (40 pp. 348-357).

Two subgenera of *Cristaria* were proposed by this author (41 pp. 409, 410). These are: 1. *Septaria*, with reticulate lateral walls of the mericarps, these not disintegrating and the locules, therefore, closed even in fruit; wings (sometimes rudimentary or obsolete) inserted at apex of the carpel in a vertical or subvertical position so that the fruit appears elongate; columella elongate. 2. *Aseptaria*, with the lateral walls disintegrating, the locules in fruit

⁸ In *G. pilosa* K. Schum. and *G. Gürkeana* K. Schum. the endoglossum is reduced to a very small, bi- or tri-cornute appendage.

more or less open bilaterally, as in *Anoda*; carpels with large wings oblique to the apex of the short columella, making the fruit appear depressed discoid.⁹

51. *Briquetia* Hochr., 1902.—This genus was based by Hochreutiner (35 pp. 11, 12), upon *B. ancylocarpa* Hochr., of Paraguay. Chodat and Hassler (11 p. 296) identified this plant with the species described by Schumann (73 p. 357, t. 65) as *Anoda denudata* (Nees & Mart.) K. Schum. of southern Brazil and Paraguay, and published the combination *Briquetia denudata* (Nees & Mart.) Chod. & Hassler. R. E. Fries (15 p. 40) concurred and gave *Wissadula Balansae* E. G. Baker as an additional synonym. Hochreutiner, in his original description, mentioned that *B. ancylocarpa* has the aspect of *Wissadula periplocifolia*. The identity of *B. ancylocarpa* and *B. denudata* was questioned, however, by Hochreutiner (36 pp. 187, 188) so there may be two species of *Briquetia*.

The outstanding character that distinguishes *Briquetia* from *Sida* and other related genera is the presence of two long hooks ("crochets") at the base of the carpel. Hochreutiner (36 p. 187) pointed out the analogy, in this respect, of *Neobrittonia* in the Abutilinae to *Briquetia* in the Sidinae, but whereas, in the former genus, which has pluriovulate loculicidal carpels, the hooks are borne on the median nerve, in *Briquetia*, which has uniovulate indehiscent carpels, they are borne laterally, on the basal angles. He mentioned also (40 p. 380) the presence of a third hook, borne at the upper angle of the carpel.

52. *Abutilothamnus* Ulbr., 1915.—A monotypic genus, based by Ulbrich (85 pp. 316-318) upon *A. grewiaefolius* Ulbr. of the Amazon region, Brazil. The plant is a shrub or small tree, with fruit stated to be very like that of *Abutilon*, but the solitary pendulous ovule with a dorsal raphe allies the plant to *Sida*. A distinguishing character of the genus is the connation of the stamen-tube, for nearly half its length, with the petals.

53. *Tetrasida* Ulbr., 1916.—Based by Ulbrich (86 pp. 66-68; 87 pp. 533-534) upon a tall shrub or small tree of Peru, *T. polyantha* Ulbr., the genus is monotypic, so far as is known. Ulbrich at first considered it to be related to *Bastardiopsis*, Hassler, but the fruit proved to be very different. The absence of an involucre and the solitary, pendulous ovule would indicate relationship to *Sida*, as Ulbrich pointed out, but the 4-lobed calyx, with lobes somewhat unequal, and the almost completely loculicidal carpels make this a very distinct genus.

54. *Sida* L., 1753. (*Sidastrum* E. G. Baker, *Disella* Greene).—A very large genus, but authorities differ so widely in their interpretations of the species that a close estimate of the total number is impossible. K. Schumann (74 p. 42) estimated about 70 species, and some 110 species, not formally reduced to synonymy or transferred to other genera, have been published since

⁹ Krapovickas (54c) concluded that *Lecanophora* is a valid genus, coinciding with Hochreutiner's subgenus *Septaria* and comprising 5 species, all Argentinian. Of these, 3 species have exalate carpels and the others have well-developed wings.

1895. Lemée (55) gave the total as more than 180 species. Of these approximately two-thirds belong to the New World.

Schuman (ibid. p. 43) grouped the species in 5 sections, as follows: 1. *Pseudomalachra* K. Schum. (*S. ciliaris* L. etc.); 2. *Physalodes* (*Calyxhymania*) A. Gray (*S. physocalyx* A. Gray, etc.); 3. *Steninda* Griseb. (*S. liifolia* Cav.); 4. *Malvinda*, (Medic.) DC. (*S. spinosa* L. etc.); 5. *Pseudomalvastrum* A. Gray (*S. leprosa* (Orteg.) K. Schum. etc.). To these he added subsequently (75 p. 238) a sixth section, *Thyrsinda* K. Schum., comprising *S. paniculata* L. etc. This classification was followed by Rodrigo (64) in her monographic treatment of the Argentinian and Uruguayan species. A seventh section, *Pseudonapaea* A. Gray, contains only one species, *S. hermaphrodita* (L.) Rusby, a plant of the eastern-central United States that resembles superficially *Napaea dioica* L. Finally R. E. Fries (17 pp. 14-19) proposed the name *Oligandrae* for a section (Artgruppe) comprising 8 South American species, of which *S. palmata* Cav. is the best known. These plants are apparently all annual, and have palmately lobed leaves, paniculate and usually numerous flowers, red-purple petals (so far as known), few stamens, and biaristate carpels with long retrorsely barbed awns.

By far the greater number of the species belong to section *Malvinda* or *Eusida*, of which such widely distributed species as *S. spinosa* L. and *S. rhombifolia* L. are typical. Section *Physalodes* is characterized by a greatly accrescent calyx. Section *Pseudomalvastrum*, for which the name *Disella*, as a genus, was proposed by Greene (24) is supposed to be distinguished by the presence of an involucl of 3 small bractlets, and in that respect is anomalous in the genus *Sida*. The involucl is present in *S. leprosa* (Orteg.) K. Schum. and often in *S. hederacea* (Dougl.) Torr., but in the latter species it is caducous. These two species appear to be congeneric with *S. Sherardiana* (L.) Benth., of southeastern Europe and western Asia, the type of the genus *Malvella* Jaub. & Spach. The other species included in Section *Pseudomalvastrum* by Gray (23 pp. 321, 322) and in *Disella* by Greene (*S. lepidota* A. Gray, *S. cuneifolia* A. Gray), seem, however, to be quite destitute of an involucl.

A genus *Sidastrum* was published by E. G. Baker (3 pp. 137, 138) with *S. quinquenervium* (Duchass.) E. G. Baker (*Sida quinquenervia* Duchass., *S. guianensis* K. Schum.) as the type. The plant was described by Baker as frutescent but, according to Standley (80 p. 253) it is a coarse herb with rather showy yellow flowers, ranging from the Canal Zone to Brazil. The character upon which Baker based the genus is "the presence of from 6-8 linear bracts" shortly below the calyx. These however, do not form a true involucl and Baker himself quoted Triana and Planchon to the effect that "the false involucl is morphologically formed of a leaf reduced to a filament with its two tripartite stipules." As Oliver expressed it (58) "the coherent 'bracteoles' very probably are the equivalents of the often 2- or 3-fid stipules." Substantially the same interpretation was given by Schumann (75 p. 238) who stated that Garcke concurred with him. Flowers closely subtended by narrow bracts are found in other species of *Sida*, e.g. *S. ciliaris* L., which is

peculiar also in having the peduncle often adnate to the subtending petiole. There seems to be little justification for maintaining *Sidastrum* as a genus.

As is evident from the foregoing analysis *Sida*, like *Malvastrum*, is a very diverse genus. It may well be that both of these genera are polyphyletic. The pendulous ovule seems to be the best character to distinguish *Sida* from species of *Malvastrum* that lack an involucre, and from certain uniovulate species of *Sphaeralcea* which have the upper (dehiscent) section of the carpel greatly reduced. Hochreutiner (40 p. 361) stated that in most species of *Sida* the carpels open by an apical cleft that is insufficient to let the seed escape. Also (41 p. 408) that none of the species have a well-developed carpocrater or septate carpels. The writer has observed, in *S. rhombifolia* L., attachment of the carpels to the axis or columella by a very slender ligament or carpophore, apparently a fibro-vascular branch of the midnerve of the carpel. This character, common in *Sphaeralcea* and several other genera, is apparently rare in *Sida*.

55. *Anoda* Cav., 1785. (*Sidanoda* Woot. & Standl.)—An exclusively American genus, monographed by Hochreutiner (38) in 1916. He recognized 15 species, ranging from the southwestern United States and the West Indies to Brazil and Chile. Most of the species are North American, with Mexico as the center of distribution. Hochreutiner (38 p. 39) classified the genus in 5 sections: 1. *Periptera* K. Schum.; 2. *Sidanoda* A. Gray, comprising only *A. abutiloides* A. Gray; 3. *Euanoda* A. Gray (*A. cristata* Schlecht. and *A. Wrightii* A. Gray); 4. *Cleistanoda* A. Gray (*A. acerifolia* DC., *A. crenatiflora* Ortega, etc.); 5. *Caryopsanoda* Hochr. (*A. pubescens* Schlecht., *A. pentaschista* A. Gray, etc.). With the exception of Section *Periptera*, treated in this paper as a separate genus, Hochreutiner's sections are based upon the character of the inner carpel-wall or endocarp, in relation to the seed. In *Sidanoda* the wall does not become detached and concrescent with the seed, and is not reticulate. In *Euanoda* the carpels are long-spurred dorsally and the very thin endocarp, becoming detached from the pericarp, attaches itself closely to the seed. In *Cleistanoda* and *Caryopsanoda* the carpels have merely an angle or a low knob on the back and are double-walled, the inner wall becoming detached from the outer wall; but whereas, in *Cleistanoda*, the reticulate inner wall becomes a sac-like envelope of the seed, in *Caryopsanoda*, as the name indicates, the inner wall becomes fused to the seed, in the manner of an outer seed-coat.

It would seem that practically the distinction between *Caryopsanoda* and *Sidanoda* would be difficult to apply and in fact Gray, in establishing Section *Sidanoda* (22 pp. 299-300) included in it not only *A. abutiloides* but two species, *A. pentaschista* and *A. Thurberi*, which Hochreutiner transferred to his Section *Caryopsanoda*. Wootton and Standley (91 p. 427) raised *Sidanoda* to the rank of a genus, with *Anoda pentaschista* A. Gray as the type species.

56. *Periptera* DC., 1824.—De Candolle (12 p. 459) established this genus with a single species, *P. punicea* (Lag.) DC. It has been merged in *Anoda*

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by most later authors, including Hochreutiner (38 pp. 38, 41-43) but was resurrected by Rose (67 pp. 173-174). A synopsis of the genus was published by Bullock (8), who recognized 4 species, all Mexican.

Later authors have followed Decandolle in distinguishing *Periptera*, whether as a genus or a section of *Anoda*, mainly because of the narrow erect petals and the very slender, greatly exerted stamen-tube. It should be noted, however, that certain species of *Abutilon* and of *Hibiscus* differ, in much the same way, from the bulk of the respective genus. A character that has been little noticed, although mentioned by Hochreutiner (38 p. 42) is the sub-clavate apical thickening of the style-branches in *Periptera*, the stigmas being obliquely truncate and very slightly decurrent. In *Anoda*, on the other hand, the stigmas are capitate or discoid and much larger than the apices of the slender style-branches. This character, together with those already mentioned, the more woody stems, and the red (not yellow or purple) color of the petals seem to warrant recognition of *Periptera* as a genus distinct from *Anoda*, although the fruit was described by Hochreutiner in his monograph of *Anoda* (38 pp. 38, 39) in almost identical terms for his sections *Periptera* and *Cleistanoda*.

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* Synonyms are italicized.

Plants of Fairview Mountain, Calapooya Range, Oregon

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LOCATION

Fairview Mountain is located in the Bohemia District, southeastern Lane County, Oregon. The mountain is part of the Calapooya Range, a subsidiary chain connecting the Cascades and Coast range at the head of the Willamette Valley. It is 32 air miles west of the main crest of the Cascade Divide and is one of the highest peaks in this region, reaching an elevation of 5933 feet.

PHYSIOGRAPHY AND TOPOGRAPHY

The lower boundary of the area studied corresponds closely to the 4500 foot contour line on the U. S. G. S. topographic map of the Lowell Quadrangle.

The steep often precipitous north slope is drained by Crystal Creek and Golden Curry Creek which flows into Champion Creek. The west slope drops down into the Sharps Creek watershed, and the south slope is cut by City Creek Canyon. The streams on the east slope empty into Champion Creek which flows northeast and in the largest stream in the region.

According to Smith (1938: 32-40) the lower part of the Calapooya formation is dominantly sedimentary, while the upper part is mostly igneous. The lower or sedimentary phase of the Calapooya is made up for the most part of pyroclastics or coarse breccias and agglomerates, all of these being different facies of volcanic materials of more or less explosive origin. Mud flows are also present. The upper igneous phase consists largely of different types of andesitic, dacitic and basaltic flows. The mountains in this area are made up predominantly of tertiary sediments and related intrusive igneous rocks, basalts and andesites, which are the result of folding and faulting, peneplanation and later dissection by rejuvenated streams. They do not seem to present any regular pattern. The topography is in that stage usually designated as mature.

CLIMATE

Fairview Mountain is situated in a region which has a marine climate of the cool dry summer type. This is due to its proximity to the Pacific ocean about 75 miles to the west.

The prevailing winds are westerly carrying moisture from the ocean. During the winter months these moisture laden winds blow over cooler land masses and are forced to ascend the mountain slopes which causes condensation and

results in a heavy precipitation. In summer months little rainfall occurs because the prevailing winds come from a relatively cool ocean and traverse warm land masses.

The nearest weather stations are located at Black Butte, Rujada,* Cottage Grove, Oakridge and Musick. The annual rainfall at Rujada, 1,212 feet elevation, is 48.28 inches most of which falls from October to May. The rainfall at Musick, 5,530 feet elevation, is 84.76, nearly double the amount at Rujada. This indicates that the precipitation increases sharply at higher elevations. The annual rainfall on Fairview Mountain, 5,933 feet elevation, is probably closer to the figure for the Musick station.

Very little moisture appears to be available during the season when temperatures are favorable to plant growth. The rainfall during June, July and August is less than 6 inches. Although summer thunder showers are frequent and quite heavy, most of them are of very short duration. Most of the water is dissipated in a quick run off and it is not held in the shallow rocky soil that is so characteristic of the region.

The growing season ranges from 90 to 120 days in average years. The average January temperature is around 35 degrees while the average July temperature is usually about 65 degrees.

There is a considerable annual snow-fall which is important in considering the growth of plant life on the mountain. The snow melts early in the season on the warm scuth slope. Moisture is made available in this way over a longer period during the summer. Many plants are found growing along the edge of the receding snow banks.

LIFE ZONES

Only three vegetational or life zones are recognized, if the scheme resulting from studies by Merriam (1898) of life zones is used, because this mountain does not reach an altitude that would produce a typical alpine flora. A number of plants are found growing here that inhabit the Arctic-Alpine Zone of the Cascades; however, this fact is probably more interesting than significant and would hold no great importance in this study as the plants are found growing in the Hudsonian Zone of the Cascades also.

The Hudsonian Zone is usually a narrow strip seldom over 1000 feet in vertical height and ranging from about 5000 to 6000 feet, although varying circumstances may alter this. It must be kept in mind that these zones are not level altitudinal lines and that the indicator plants merely reach their maximum development or abundance within them. The trees of the Hudsonian zone extend up the mountain sides much higher on the ridges than in the valleys between. This has been considered by Merriam partly the result of more or less favorable exposure to the sun rays, and partly to air currents, the warm currents tending to follow up the steep ridges while the cold currents flow down the valleys. Therefore, certain species ascend highest on the warm ridges, while others descend farthest into the cool valleys. It is here in the Hudsonian Zone, that you have the greatest floral display on the mountain. The growing season is short and the flowers hardly wait for the snow to melt, some of the

hardest plants growing in the very edge of the snow line. During the warm days of July the snow vanishes and the slopes burst into bloom. The plants of this zone make up 30% of the Flora of Fairview Mountain. The characteristic trees are *Tsuga Mertensiana* and *Chamaecyparis nootkatensis*. Other conspicuous plants are *Thlaspi alpestre*, *Epilobium alpinum*, *Polygonum Newberryi*, *Arenaria formosa*, *Phlox diffusa* var. *longistylis*, *Senecio integerrimus* and *Penstemon rupicola*.

The Canadian Zone is the least well defined zone on the mountain. Many so called Canadian species range down into the Transition Zone and sharp lines of division between these two regions cannot be drawn. It is a mountain zone which can be considered to range from about 4000 to 5000 feet in this area. It is often characterized by an increase in the percentage of *Tsuga heterophylla* and *Abies grandis* present. It should be noted that both these are also found in the Transition zone. *Pinus monticola* seems to be the most characteristic representative of the Canadian life zone here on Fairview Mountain. The appearance of *Xerophyllum tenax* on the slopes of the mountain is also a good indicator. Piper (1906: 59) summarizes the situation as follows: "The zone can, in fact, be recognized not so much by any purely characteristic species as by the great abundance of species relatively rare in contiguous zones." This is also an area in which many shrubs and small trees abound such as: *Acer circinatum*, *Alnus sinuata*, *Vaccinium membranaceum*, *Sorbus cascadiensis*, *Arctostaphylos nevadensis*, *Vaccinium ovalifolium*, *Pachistima myrsinites* and *Vaccinium scoparium*. Many of the species in the Canadian zone are those whose ranges extend much farther northward.

The Transition Zone is also represented on the mountain at lower altitudes. Allowance being made for overlap in zones, the Transition region extends upward to about 4500 feet. In view of the boundaries defined for the mountain it will be noted that much of the Transition zone would remain below our limits. However, there are still about 29 percent of the plants growing here that must be classed as typical of the Transition zone. The most characteristic species of the zone are *Pseudotsuga taxifolia*, *Libocedrus decurrens*, *Taxus brevifolia*, *Abies grandis*, *Tsuga heterophylla*, *Acer macrophyllum*, *Gaultheria Shallon*, *Rubus spectabilis*, *Mimulus guttatus*, *Trillium ovatum*, *Achlys triphylla*, *Polystichum munitum* and *Pteridium aquilinum* var. *pubescens*.

THE FLORAL ELEMENTS

The flora of this area consists of plants representing three different floral provinces. These can be divided into the Northern element, Southern element, and Eastern Element. It is interesting to note that both Piper and Beattie (1915) and Gilkey (1947) in their regional floras have taken this range of mountains as the southern limit of the area covered.

The Northern or Alaskan element in the flora comprises most of the plants found growing in the Hudsonian zone and many of the plants of the Canadian zone. There are several extensions of the Northern element worthy of consideration. *Luina stricta* and *Haplopappus Hallii* have been previously

reported only from northern Oregon. The former was long considered an endemic of Washington. It is interesting to observe the occurrence of this plant here. It may yet be found at intermediate stations when the botanical exploring of these areas is done more intensively.

The Eastern element consists of those plants which are common east of the Cascade Mountains and are of Blue Mountain, Great Basin, or Rocky Mountain origin. These plants are not normally found in the area west of the Cascade Mountains. Some swing around to the south of the region and have



Plate 1.—Fairview Mountain, north slope (upper); South slope (lower).

been reported from California. A considerable number have not been reported previously in the state except from eastern Oregon and may be considered extensions of range. Ordinarily the extension of a plant for 50 miles or so, would not be unusual but in this area the high mountain barrier of the Cascades is a phytogeographical feature of no small importance. Plants are not usually adapted to the varied conditions of the humid western side of these mountains, as well as the arid regions which are found on the east side.

The Southern element in our flora is predominantly of California origin. The extreme southern end of the Willamette Valley and the northern end of the Umpqua Valley are very much alike floristically, as would be expected since they are separated by only a narrow ridge of mountains. Within a few miles of the summit of the Calapooya divide the vegetation of these two areas may be said to meet and on both sides of the divide we have a commingling of the flora. The character of the flora is greatly influenced by the climate and soil. The rainfall in the Willamette Valley decreases as we proceed southward. Across the divide in the Umpqua Valley the annual rainfall is only 35 inches; this coupled with a soil which is loose and rocky causes the rapid loss of the available moisture. The rainy season ends by early summer and the high summer temperature has a definite effect on the vegetation. These conditions are ideal for xerophytes. On the south slope of the Calapooya Mountains in the Umpqua Valley, many California plants reach their northern limit; while in the Rogue River Valley, which is the next southward, the flora is predominantly Californian.

INTRODUCED SPECIES

All species adventive on Fairview Mountain are of European origin. These total 15 species or about 5% of the total number of vascular plants found growing in the area. These species are all classed as weeds. Some of them are the most widespread and noxious weeds in our region. However, based on a comparison with other areas closer to the habitat of man, this region is comparatively low in the percentage of weeds present. The total number of introduced species in the flora of Oregon approximates 10%. This estimate is based on those species listed as introduced in *A Manual of the Higher Plants of Oregon*, by Morton E. Peck. The weed flora of Mount Hamilton Range, California, comprises 9% of the total flora as indicated by Sharsmith (1945: 312).

In the list of introduced species, 3 are monocotyledons, all grasses; while 12 are dicotyledons. All are herbaceous, 55% being annual and 65% perennial. These are as follows: *Avena fatua*, *Poa compressa*, *Poa annua*, *Rumex Acetosella*, *Rumex obtusifolius*, *Spergularia rubra*, *Brassica Kaber*, *Trifolium repens*, *Hypericum perforatum*, *Veronica arvensis*, *Plantago lanceolata*, *Sherardia arvensis*, *Hypochaeris radicata* and *Chrysanthemum leucanthemum*.

EXTENSIONS IN RANGE

Extensions of range are reported for a considerable number of plants. These represent 15 percent of the total number of species collected on Fairview Moun-

tain. The relatively high percentage is perhaps due to the fact that the area had not been collected intensively before; also the diversity of the flora has a definite bearing on the number of species likely to be found in the region. This in turn would increase the probability of finding range extensions. The area is of particular interest because: (1) it is the northern limit of a number of California species, (2) it is the southern limit of some Northern species, (3) and there is a considerable number of eastern Oregon or Great Basin plants present. The occurrence of the latter may be due to migration over the high barrier of the Cascades; or on the the other hand it may be that these plants were once common in western Oregon and due to changing climatic conditions survived only on the high mountain peaks. The conditions on the peaks closely simulate the dried habitats east of the mountains.

The occurrence of *Lonicera utahensis* on Fairview is of special interest since it is not known from the Cascade mountains at all. This is a good example of discontinuous distribution. A check on material in several herbaria indicates that it does occur in the Blue Mountains. This is the nearest locality record to our region. Another species which should be mentioned is *E. igeroni cascadenis*. This rare plant is nearly endemic to the Calapooya Range. It is apparently found only on high mountain peaks above the watershed of the Umpqua River and adjacent ranges. The plant is quite common at the summit of both Fairview and Bohemia Mountains. According to Cronquist (1947: 218) collections have been made at Mt. Scott, Klamath-Jackson counties; Amabilis Peak, Calapooya Mountains; 45th parallel, Cascade Mountains; Hershberger Butte, Douglas County; and on a rocky bank, Pansy Camp, Cascade Mountains (Type) Howell.

SUMMARY OF PLANTS

Three hundred seventeen different species of plants are known to grow on Fairview Mountain. The largest families are Compositae (16 genera, 27 species), Gramineae (12 genera, 23 species), Saxifragaceae (11 genera, 22 species), Rosaceae (9 genera, 19 species), and Scrophulariaceae (8 genera, 18 species). Some other important families with the total number of species are as follows: Polygonaceae (14), Leguminosae (14), Ericaceae (14), Liliaceae (12), Ranunculaceae (11), Onagraceae (10), Umbelliferae (9), Cruciferae (8), and Caprifoliaceae (8). The 317 species represent close to 10 percent of the total of 3203 species listed by Peck (1941) for the state of Oregon. Fifty-one families are represented in the flora of the mountain, or 43 percent of the 118 families that occur in Oregon. Considering the limited area collected this appears to be a fairly diverse flora.

Groups	Families	Genera	Species
Pteridophytes	1	10	13
Gymnosperms	3	7	9
Monocotyledons	5	29	55
Dicotyledons	42	138	240
Totals	51	184	317

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ANALYTICAL KEY TO THE FAMILIES

- Plants reproducing by spores Division I. PTERIDOPHYTA
Plants reproducing by seeds Division II. SPERMATOPHYTA

Division I. PTERIDOPHYTA

- Spores borne on the under surface of the leaves 1. Polypodiaceae

Division II. SPERMATOPHYTA

- Seeds not enclosed in an ovary, usually borne on the face of a cone scale Class I. GYMNOSPERMAE
Seeds enclosed in an ovary Class II. ANGIOSPERMAE

Class I. GYMNOSPERMAE

- Fruit red, one-seeded, berry-like or drupe-like 2. Taxaceae
Fruit a several-seeded cone
Leaves scale-like 4. Cupressaceae
Leaves linear, fascicled or scattered along the branch 3. Pinaceae

Class II. ANGIOSPERMAE

- Leaves usually parallel veined, parts of the flower commonly in 3's, vascular bundles scattered throughout the stem, one seed leaf Sub-class I. Monocotyledones
Leaves usually netted veined, parts of the flower commonly in 4's or 5's, vascular bundles arranged concentrically around a central pith, two seed leaves Sub-class II. Dicotyledones

Sub-class I. MONOCOTYLEDONES

- Plants grass-like; flowers inconspicuous
Perianth none
Stems hollow, cylindrical; leaves two-ranked; fruit a caryopsis 5. Gramineae
Stems solid, usually three-angled; leaves three-ranked; fruit an achene 6. Cyperaceae
Perianth present, glume-like 7. Juncaceae
Plants not grass-like, flowers generally showy
Ovary superior 8. Liliaceae
Ovary inferior 9. Orchidaceae

Sub-class II. DICOTYLEDONES

Petals None

- Trees and shrubs
Staminate and pistillate flowers both borne in catkins
Fruit a capsule, many ovuled 10. Salicaceae
Fruit a cone or berry, 1 or 2 ovuled
Fruit a woody cone 11. Betulaceae
Fruit berry-like 33. Garryaceae
Staminate flowers, only, borne in catkins 12. Fagaceae

Herbs

- Ovary superior
 - Pistils many17. Ranunculaceae
 - Pistil one14. Polygonaceae
- Ovary inferior; leaves heart-shaped13. Aristolochiaceae

Petals Present

Petals Free, or Only Slightly Joined at Base

- Ovary superior
 - Stamens borne at the base of the calyx lobes and fused with other parts of the hypanthium
 - Stamens 12 or fewer22. Saxifragaceae
 - Stamens many23. Rosaceae
 - Stamens not as described above
 - Leaves palmately compound with 3 leaflets26. Oxalidaceae
 - Leaves not as above
 - Sepals 2 (ours)15. Portulacaceae
 - Sepals more than 2
 - Plants with succulent, fleshy leaves21. Crassulaceae
 - Plants with leaves not as above
 - Stamens indefinite in number17. Ranunculaceae
 - Stamens definite in number
 - Leaves alternate
 - Petals 420. Cruciferae
 - Petals more than 4
 - Corolla irregular
 - Flowers with a spur30. Violaceae
 - Flowers papilionaceous24. Leguminosae
 - Corolla regular
 - Petals 6; stamens 6; anthers opening by uplifted valves18. Berberidaceae
 - Petals 5; stamens 5; anthers not as above25. Linaceae
 - Leaves opposite
 - Stamens in groups; styles 329. Hypericaceae
 - Stamens not as above
 - Large or small trees28. Aceraceae
 - Herbs or shrubs
 - Evergreen shrub (ours)27. Celastraceae
 - Herbaceous plants16. Caryophyllaceae
 - Ovary inferior
 - Flowers in umbels32. Umbelliferae
 - Flowers not in umbels
 - Fruit a pome23. Rosaceae
 - Fruit not as above
 - Perianth parts in 5's (occasionally 4's); styles 2-522. Saxifragaceae
 - Perianth parts in 4's (rarely 2's); style 1
 - Fruit fleshy; flowers; flowers surrounded by showy petal-like bracts; stamens 434. Cornaceae
 - Fruit dry; flowers in racemes or spikes; stamens 2 or 8; flower parts in 4's or 2's31. Onagraceae

Petals More or Less United

- Stamens more than 5
 - Petals united only at the base, or, if united upwards, stamens 6
 - Stamens 6; sepals 2; petals 4 in 2 sets19. Fumariaceae
 - Stamens 1026. Oxalidaceae
 - Petals united into an urn-shaped tube35. Ericaceae

- Stamens 5 or fewer
 Ovary superior
 Flowers regular
 Pistils 2 38. Apocynaceae
 Pistil 1
 Ovary 4-lobed, forming 4 nutlets 41. Boraginaceae
 Ovary not 4-lobed, not as above
 Stamens opposite the corolla lobes 37. Primulaceae
 Stamens alternate with the corolla lobes.
 Leaves all basal 45. Plantaginaceae
 Leaves not as above
 Style 3-cleft at apex 39. Polemoniaceae
 Style not 3-cleft
 Plant glabrous 36. Gentianaceae
 Plant hairy 40. Hydrophyllaceae
 Flowers irregular
 Leaves alternate
 Parasites with scale-like leaves 44. Orobanchaceae
 Plants with green leaves 43. Scrophulariaceae
 Leaves opposite
 Ovary 4-lobed, forming 4 nutlets 42. Labiatae
 Ovary a capsule, not as above 43. Scrophulariaceae
 Ovary inferior
 Plants mostly monoecious 49. Cucurbitaceae
 Plants not as above
 Leaves alternate or basal
 Flowers bell-shaped 50. Campanulaceae
 Flowers involucrate and in heads 51. Compositae
 Leaves opposite or whorled
 Stamens united in a ring or tube around the style 51. Compositae
 Stamens not united, not as above
 Shrubs, erect or twining 47. Caprifoliaceae
 Herbs
 Flower parts in 4's 46. Rubiaceae
 Flower parts not as above (corolla 5-lobed) 48. Valerianaceae

ANNOTATED CATALOGUE OF PLANTS

Pteridophyta—Ferns and Fern-allies

1. POLYPODIACEAE—Fern Family

- Indusium present (often apparently or quite absent in *Athyrium americanum*)
 Sori marginal, covered by the revolute portion of the leaf
 Fronds of two kinds
 Sterile leaf blades simple pinnate 6. *Struthiopteris*
 Sterile leaf blades 2-3 pinnate 10. *Cryptogramma*
 Fronds alike
 Plants with fan-shaped pinnules 7. *Adiantum*
 Plants with pinnules not as above
 Plants large and stout; fronds usually solitary 8. *Pteridium*
 Plants small and slender; fronds generally clustered 9. *Cheilanthes*
 Sori not marginal, borne on the veins
 Indusia partially inferior 1. *Cystopteris*
 Indusia superior
 Sori oblong, lunate 5. *Athyrium*
 Sori round
 Indusium orbicular, centrally peltate 3. *Polystichum*

- Indusium reniform, attached at its sinus4. *Dryopteris*
Indusium wanting2. *Polypodium*

1. CYSTOPTERIS Bernh.

1. *Cystopteris fragilis* (L.) Bernh. Bladder fern.—Growing on a cliff near Bohemia saddle; occasional. Hudsonian.

2. POLYPODIUM L.

- Fronds thin, 20-40 cm. long; pinnae acute or acuminate, linear attenuate
.....1. *P. Glycyrrhiza*
Fronds small, 5-15 cm. long; pinnae obtuse, short2. *P. hesperium*
1. *Polypodium Glycyrrhiza* D. C. Eaton. Licorice fern.—Along stream on north slope common. Humid Transition.
2. *Polypodium hesperium* Maxon. Mountain licorice fern.—Growing at top of north-slope among rocks; not common. Hudsonian.

3. POLYSTICHUM Roth.

- Pinnae linear-attenuate, the teeth pointing upward2. *P. munitum*
Pinnae deltoid-lanceolate, the teeth pointing outward1. *P. Lonchitis*
1. *Polystichum Lonchitis* (L.) Roth. Holly-fern.—On north slope near top, growing among boulders and rocks; occasional. Hudsonian.
2. *Polystichum munitum* (Kaulf.) Presl.—Common sword fern. In woods of north slope and at lower elevations along Utopian Way; fairly common. Humid Transition.

4. DRYOPTERIS Adans.

1. *Dryopteris dilatata* (Hoffm.) Gray. Spreading wood-fern.—Along stream banks in woods of north slope; fairly common. Humid Transition and Canadian.

5. ATHYRIUM Roth.

- Indusia lunate, present; pinnules sessile2. *A. Filix-femina*
Indusia evanescent; pinnules short stalked, somewhat cuneate at base1. *A. americanum*
1. *Athyrium americanum* (Butters) Maxon. Alpine lady-fern.—On north slope near summit of the mountain; occasional. Hudsonian.
2. *Athyrium Filix-femina* (L.) Roth. Lady-fern.—About springs and watercourses; common. Transition and Canadian.

6. STRUTHIOPTERIS Scop.

1. *Struthiopteris spicant* (L.) Weis. Deer-fern.—Common along watercourses and in dense forests on north slope. Humid Transition.

7. ADIANTUM L.

1. *Adiantum pedatum* L. var. *aleuticum* Rupr. Western maidenhair fern.—West slope along Utopian Way; common. Humid Transition and Canadian.

8. PTERIDIUM Scop.

1. *Pteridium aquilinum* (L.) Kuhn var. *pubescens* Underw. Western bracken.—Common around Musick Guard Station. Humid Transition to Hudsonian.

9. CHEILANTHES Sw.

1. *Cheilanthes gracillima* D. C. Eaton. Lace-fern.—Common on summit growing on rock slopes and out-croppings. Hudsonian.

10. CRYPTOGRAMMA R. Br.

1. *Cryptogramma acrostichoides* R. Br. American parsley-fern.—Fairly common at high elevations among rocks. Hudsonian.

Spermatophyta—Seed Plants

Class GYMNOSPERMS—Cone-bearing plants

2. TAXACEAE—Yew Family

1. TAXUS L.

1. *Taxus brevifolia* Nutt. Western Yew.—Found along Utopian Way; scattered. Humid Transition and Canadian.

3. PINACEAE—Pine Family

Leaves in clusters, 2 to 5 in a bundle1. *Pinus*

Leaves solitary, opposite or whorled, scattered along the branch

Cones erect; scales deciduous3 *Abies*

Cones pendulous; scales persistent

Branchlets smooth; leaves persistent when dried, bracts exceeding the scales

.....2. *Pseudotsuga*

Branchlets roughened by the persistent leaf bases; leaves deciduous when dried, scales longer than the bracts4. *Tsuga*

1. PINUS L.

1. *Pinus monticola* Dougl. Western white pine.—Occurs on north slope and Elephant saddle; common. The characteristic tree of the Canadian zone.

2. PSEUDOTSUGA Carr.

1. *Pseudotsuga taxifolia* (Lamb.) Britt. Douglas fir.—Common on south slope and along Musick Mine Road. Humid Transition and Canadian.

3. ABIES (Tourn.) Hill

Cones green; leaves notched at apex2. *A. grandis*

Cones purple, large; leaves generally acute1. *A. amabilis*

1. *Abies amabilis* (Dougl.) Forbes. Lovely fir.—Growing on south slope Fairview Bohemia saddle and along headwaters of City Creek near Musick Mine; common. Canadian.

2. *Abies grandis* Lindl. Grand fir.—Very common at low elevations on north slope and growing up to summit in scattered stands. Humid Transition and Canadian.

4. TSUGA (Engl.) Carr.

Leaves in flattened sprays; cones small, $\frac{1}{2}$ to 1 inch long1. *T. heterophylla*

Leaves spreading from all sides of the stem; cones larger, 1-1 $\frac{1}{2}$ to 3 inches long

.....2. *Mertensiana*

1. *Tsuga heterophylla* (Raf.) Sarg. Western hemlock.—Very abundant in forests of lower elevations at base of the mountain. Humid Transition and Canadian.

2. *Tsuga Mertensiana* (Bong.) Sarg. Mountain hemlock.—On north and west slopes, forming principal tree at timberline. Hudsonian.

4. CUPRESSACEAE—Cypress Family

Cones oblong; scales oblong, imbricated; leaves appearing to be in whorls of four

.....1. *Libocedrus*

Cones globose; scales shield or wedge-shaped; leaves in pairs2. *Chamaecyparis*

1. LIBOCEDRUS Endl.

1. *Libocedrus decurrens* Torr. Incense cedar.—Present on south slope at headwaters of City Creek. Common in the dry more arid region to the south. Arid Transition.

2. CHAMAECYPARIS Spach.

1. *Chamaecyparis nootkatensis* (Lamb.) Spach. Alaska cedar.—Common on west slope above Utopian Way where there is a considerable grove. South slope near Musick Mine,

also several small trees at the summit. This tree practically reaches its southern limit here, although trees have been reported from northern California. It is best developed in its range in southeastern Alaska and British Columbia where it is of considerable importance as a lumber tree. Canadian and Hudsonian.

MONOCOTYLEDONS

5. GRAMINEAE—Grass Family

Spikelets with several to many flowers

Inflorescence a panicle

Glumes shorter than the lemma; awn apical and straight or none at all Tribe 1. *Festuceae*

Glumes longer than the lemma; awn dorsal, bent and twisted Tribe 3. *Aveneae*

Inflorescence a spike Tribe 2. *Hordeae*

Spikelets with one perfect flower Tribe 4. *Agrostideae*

Tribe 1. *FESTUCEAE*

Lemmas keeled on the back

Lemmas awned from a minutely two-toothed apex 1. *Bromus*

Lemmas awnless; spikelets small, not over 8 mm. long 3. *Poa*

Lemmas rounded on the back (slightly keeled toward the summit in *Festuca* and some species of *Bromus*)

Glumes papery; upper florets sterile, folded about each other 4. *Melica*

Glumes not papery; upper florets perfect

Lemmas entire, awned from the tip or pointed 2. *Festuca*

Lemmas awned from a minutely two-toothed apex 1. *Bromus*

Tribe 2. *HORDEAE*

Rachis continuous, not readily broken into joints; glumes entire 5. *Elymus*

Rachis breaking apart at maturity into joints; glumes often parted 6. *Sitanion*

Tribe 3. *AVENEAE*

Spikelets less than 1 cm. long 7. *Trisetum*

Spikelets 2 cm. or more long 8. *Avena*

Tribe 4. *AGROSTIDEAE*

Rachilla articulating above the glumes

Glumes longer than the lemma

Florets with hairs at the base at least half as long as the lemma; palea present 9. *Calamagrostis*

Florets naked at the base or with short hairs 10. *Agrostis*

Glumes shorter than the lemma 12. *Muhlenbergia*

Rachilla articulating below the glumes 11. *Cinna*

1. *BROMUS* L.

Spikelets strongly flattened and keeled

Lemmas smooth or rough; sheaths smooth 1. *B. polyanthus*

Lemmas pubescent at least below 2. *B. marginatus*

Spikelets not strongly flattened and keeled 3. *B. vulgaris*

1. *Bromus polyanthus* Scribn. Great Basin brome-grass.—Dry open hillside; quite common. This is a plant of the Rogue River Valley to the south, that enters our limits here. It is quite common in Eastern Oregon. Arid Transition.

2. *Bromus marginatus* Nees. Large mountain brome-grass.—Quite common at summit. Transition.

3. *Bromus vulgaris* (Hook.) Shear. Narrow-flowered brome-grass.—Woods of north slope; common. Humid Transition.

2. *FESTUCA* L.

- Plants annual; stamen usually one 1. *F. megalura*
 Plants perennial; stamens three
 Lemmas awnless or nearly so 2. *F. viridula*
 Lemmas awned 3. *F. occidentalis*
 1. *Festuca megalura* Nutt. Western six-weeks fescue.—Dry open hillside; fairly common. Humid Transition.
 2. *Festuca viridula* Vasey. Mountain bunch grass.—Summit of mountain; fairly common. Hudsonian.
 3. *Festuca occidentalis* Hook. Western fescue.—Moist north slope; quite common. Transition.

3. *POA* L.

- Annual 1. *P. annua*
 Perennial
 Plants with creeping rhizomes
 Stems flattened 2. *P. compressa*
 Stems terete
 Lemma with web-like hairs at the base 3. *P. rhizomata*
 Lemma without web-like hairs 4. *P. epilys*
 Plants without creeping rhizomes 5. *P. gracillima*
 1. *Poa annua* L. Annual bluegrass.—Very common on west slope about springs and watercourses. Introduced from Europe.
 2. *Poa compressa* L. Canada bluegrass.—Very common at summit. Introduced from Europe.
 3. *Poa rhizomata* Hitch. Timber bluegrass.—Found on summit and on north slope; very abundant. Humid Transition and Canadian.
 4. *Poa epilys* Scribn. Mountain bluegrass.—Fairly common on open hillsides, east slope near summit. Hudsonian.
 5. *Poa gracillima* Vasey. Pacific bluegrass.—Abundant on summit. Canadian to Hudsonian.

4. *MELICA* L.

1. *Melica subulata* (Griseb.) Scribn. Alaska onion-grass.—North slope; rather scarce. Transition to Hudsonian.

5. *ELYMUS* L.

- Glumes and lemmas awnless or mucronate 1. *E. virescens*
 Glumes and lemmas distinctly awned 2. *E. glaucus*
 1. *Elymus virescens* Piper. Pacific Rye-grass.—Moist slope on north side; not common. Canadian.
 2. *Elymus glaucus* Buckl. Western Rye-grass.—Growing near Musick Guard Station; common. Transition.

6. *SITANION* Raf.

1. *Sitanion Hystrix* (Nutt.) J. G. Smith. Bottle-brush squirrel-tail.—Fairly common at summit of the mountain. Found very commonly in the high Cascades and eastward. Hudsonian.

7. *TRisetum* Pers.

1. *Trisetum cernuum* Trin. Nodding trisetum.—Growing on the moist north slope; common. Transition.

8. *AVENA* L.

1. *Avena fatua* L. Wild oat.—Common around Musick Guard Station. Introduced from Europe.

9. *CALAMAGROSTIS* Adans.

1. *Calamagrostis canadensis* (Michx.) Beauv.—Blue-joint.—North slope in moist places; quite common. Transition.

10. AGROSTIS L.

Rachilla prolonged behind the palea1. *A. aequivallis*
 Rachilla not prolonged behind the palea2. *A. exarata*

1. *Agrostis aequivallis* Trin. Northern bent-grass.—North slope in marshy ground; not common. Hudsonian.

2. *Agrostis exarata* Trin. Western bent-grass.—Common on north slope in marshy ground. Humid Transition.

11. CINNA L.

1. *Cinna latifolia* (Trevir.) Griseb. Slender wood reed-grass.—Moist woods along west slope, also about springs; common. Canadian.

12. MUHLENBERGIA Gmel.

1. *Muhlenbergia fliformis* (Thurb.) Rydb. Slender Muhlenbergia.—Marsh on north slope; fairly common. Hudsonian.

6. CYPERACEAE—Sedge Family

1. CAREX L.

Stigmas 3; achenes 3-angled

Perigynia slightly compressed but not strongly flattened1. *C. ablata*

Perigynia strongly flattened, oval in outline, minutely beaked

Pistillate spikes erect, sessile or short peduncled2. *C. spectabilis*

Pistillate spikes nodding on slender peduncles7. *C. Mertensii*

Stigmas 2; achenes lenticular

Lateral spikes short; terminal spike only partly staminate

Perigynia winged on the margins

Perigynia thin, flattened except as distended by the achene5. *C. festivella*

Perigynia strongly plano-convex, thick in the center

Perigynia 3 to 3.5 mm., serrulate above, somewhat flattened to the apex

.....4. *C. subfusca*

Perigynia 3.5 to 5 mm., not very serrulate, terete and smooth at the apex

.....8. *C. pachystachya*

Perigynia not winged on the margins6. *C. laevisculmis*

Lateral spikes elongated; terminal spike entirely staminate3. *C. Kelloggii*

1. *Carex ablata* Bailey. American cold-loving sedge.—In marsh on north side; common. Canadian and Hudsonian.

2. *Carex spectabilis* Dewey. Showy sedge.—Marsh on north side; very common. Hudsonian.

3. *Carex Kelloggii* W. Boott. Kellogg's sedge.—Marsh on north side; common. Hudsonian.

4. *Carex subfusca* W. Boott. Rust sedge.—Marsh on north side; common. Transition to Hudsonian.

5. *Carex festivella* Mack. Mountain meadow sedge.—In meadow on west slope; rather common. Transition.

6. *Culmis laevisculmis* Meinsh. Smooth-stemmed sedge.—West slope, marshy ground; not common. Canadian.

7. *Carex Mertensii* Prescott. Mertens' sedge.—Moist ground in woods of east slope. Canadian.

8. *Carex pachystachya* Cham. Thick-headed sedge.—Marshes and wet meadows on south and west slopes; very common. Canadian.

7. JUNCACEAE—Rush Family

Leaf-sheaths open; capsule many-seeded1. *Juncus*

Leaf-sheaths closed; capsule 3-seeded2. *Luzula*

1. JUNCUS L.

- Lower leaf of the inflorescence appearing like a continuation of the stem; inflorescence therefore appearing lateral 1. *J. effusus*
 Lower leaf not as above; inflorescence therefore appearing terminal
 Leaf blades flattened, ensiform; septa incomplete; stem 2-edged; stamens 3 (rarely 6) 2. *J. ensifolius*
 Leaf blades little flattened, not ensiform; septa complete; stem not 2-edged; stamens 6 3. *J. Mertensianus*

1. *Juncus effusus* L. Common rush.—Marsh on north side; fairly common. Transition to Canadian.
 2. *Juncus ensifolius* Wiks. Three-stamened rush.—Marshy ground of lower north slope; common. Transition and Canadian.
 3. *Juncus Mertensianus* Bong. Mertens' Rush.—Growing in a marsh on south slope; rather common. Hudsonian.

2. LUZULA DC.

- Flowers in a loose panicle, solitary on the end of the branches 1. *L. parviflora*
 Flowers congested into spikes or head-like clusters 2. *L. multiflora*
 1. *Luzula parviflora* (Ehrh.) Desv. Small-flowered wood-rush.—Common, growing at summit. Humid Transition to Hudsonian.
 2. *Luzula multiflora* (Retz.) Lejeune. Common wood-rush.—Summit of the mountain; common. Transition to Hudsonian.—*L. campestris* (L.) DC. of some American authors.

8. LILIACEAE—Lily Family

Fruit a capsule

- Sepals and petals not alike
 Leaves 3, in one whorl 10. *Trillium*
 Leaves several, not whorled 3. *Calochortus*
 Sepals and petals alike
 Plants with narrow leaves appearing grass-like 1. *Xerophyllum*
 Plants with broader leaves
 Leaves 2, rather broad, appearing to be basal 5. *Erythronium*
 Leaves several to many, not basal, stems leafy
 Flowers large, showy; inflorescence solitary or racemose 4. *Lilium*
 Flowers small, many; inflorescence paniculate 2. *Veratrum*

Fruit a berry

- Plants with leafy stems
 Flowers drooping, axillary or terminal
 Flowers axillary 9. *Streptopus*
 Flowers terminal, 1 to 2 at end of stem 8. *Disporum*
 Flowers erect, racemose or paniculate 7. *Smilacina*
 Plants with few leaves, mostly basal 6. *Clintonia*

1. XEROPHYLLUM Michx.

1. *Xerophyllum tenax* (Pursh) Nutt. Bear-grass.—Very common on open dry hillsides of southwest slope. Canadian to Hudsonian.

2. VERATRUM L.

1. *Veratrum insolitum* Jepson. Siskiyou false hellebore.—Locally abundant on open hillside of south slope. Found commonly in southern Oregon and northern California and recently reported from Benton County. It differs from others of the same genus in this region by having perianth parts fimbriate and a densely woolly ovary. This is an extension of the known range of this species. Humid Transition.

3. CALOCHORTUS Pursh

1. *Calochortus Lobbii* (Baker) Purdy. Alpine cat's ear.—Very common at summit. Hudsonian.

4. LILIUM L.

1. *Lilium Washingtonianum* Kell. Cascade lily.—Open ground at summ't just west of lookout tower; common. Arid Transition.

5. ERYTHRONIUM L.

Perianth white; stigma nearly entire 1. *E. klamathense*

Perianth bright yellow; stigma distinctly lobed 2. *E. grandiflorum*

1. *Erythronium klamathense* Appleg. Klamath fawn lily.—Open hillside on the north slope; rare. This is a rare and unusual white species found for the first time this far north. It is reported from Crater Lake National Park on the west slope. Hudsonian.

2. *Erythronium grandiflorum* Pursh var. *pallidum* St. John. Yellow fawn lily.—North slope near edge of receding snow; common. Hudsonian.

6. CLINTONIA Raf.

1. *Clintonia uniflora* (Schult.) Kunth. Queen's cup.—Common on wooded north slope. Canadian.

7. SMILACINA Desf.

Inflorescence a few-flowered raceme 1. *S. sessilifolia*

Inflorescence a many-flowered panicle 2. *S. racemosa*

1. *Smilacina sessilifolia* (Baker) Nutt. Small false Solomon's seal.—Common on north-west slope. Humid Transition and Canadian.

2. *Smilacina racemosa* (L.) Desf. Large false Solomon's seal.—Very common in shaded humus soil of the northwest slope. Humid Transition.

8. DISPORUM Salisb.

1. *Disporum oreganum* (Wats.) W. Miller. Fairy bells.—Common on east slope and at base of St. Peter's Rock. Humid Transition.

9. STREPTOPUS Michx.

1. *Streptopus amplexifolius* (L.) DC. Twisted stalk.—Marsh at Musick Mine; not common. Canadian.

10. TRILLIUM L.

1. *Trillium ovatum* Pursh. Wood lily.—Very abundant on north slope in cool moist woods, also springing up along receding snow banks. Humid Transition and Canadian.

9. ORCHIDACEAE—Orchid Family

Plants with green foliage leaves present

Leaves 2, opposite, borne near middle of stem 3. *Listeria*

Leaves several, alternate or basal

Flowers with a spur 1. *Habenaria*

Flowers without a spur 2. *Goodyera*

Plants not green; leaves reduced to scales 4. *Corallorhiza*

1. HABENARIA Willd.

Leaves basal; stem leaves bract-like, usually withered by flowering time 1. *H. unalascensis*

Leaves not basal; stems leafy, leaves not withered as above 2. *H. saccata*

1. *Habenaria unalascensis* (Spreng.) Wats. Alaska bog orchid.—Fairly common in marshes on north slope of the mountain. Canadian.

2. *Habenaria saccata* Greene. Green bog orchid.—Quite common in marshes at Musick Mine and on north slope. Hudsonian.

2. GOODYERA R. Br.

1. *Goodyera oblongifolia* Raf. Rattlesnake plantain.—Common in dense coniferous woods on west slope. Transition.—*G. decipiens* (Hook.) F. T. Hubbard.

3. LISTERA R. Br.

Lip 9 mm. long, 2 lobed at apex; ovary glandular 1. *L. convallarioides*
Lip 6 mm. long, spatulate or retuse; ovary glabrous 2. *L. caurina*

1. *Listera convallarioides* (Sw.) Torr. Twayblade.—In densely shaded woods with the following species; not common. Canadian.

2. *Listera caurina* Piper. Northwestern twayblade.—In densely shaded woods along Utopian Way; rare. Canadian.

4. CORALLORHIZA R. Br.

Lip purple-spotted, 3-lobed; spur attached almost its entire length 1. *C. maculata*
Lip purple, not spotted, entire or toothed; spur free below the middle 2. *C. Mertensiana*

1. *Corallorhiza maculata* Raf. Spotted coral-root.—West slope of Utopian Way; not common. Canadian.

2. *Corallorhiza Mertensiana* Bong. Purple coral-root.—Scattered along trail on south-west slope. Canadian.

DICOTYLEDONS

10. SALICACEAE—Willow Family

1. SALIX (Tourn.) L.

Capsules glabrous; stamens 4 to 8 1. *S. lasiandra*
Capsules pubescent; stamens 1 or 2

Leaves satiny beneath, coetaneous with the catkins; stamen one 2. *sitchensis*
Leaves glabrous, short-pubescent, or tomentose, not satiny; precocious; stamens 2

..... 3. *S. Scouleriana*
1. *Salix lasiandra* Benth. Red willow.—Common on north slope along banks of Crystal Creek. Humid Transition.

2. *Salixitchensis* Sans. Sitka willow.—Along edge of stream on north slope. Hudsonian.

3. *Salix Scouleriana* Barr. Scouler's willow.—On open hillsides of south slope, also on edge of marsh at Musick Mine, headwaters of City Creek. Frequent along streams on north slope. Very common. Canadian.

11. BETULACEAE—Birch Family

1. ALNUS Hill.

1. *Alnus sinuata* (Regel) Rydb. Sitka alder.—Abundant along waterways and wet places on north slope, also along Utopian Way. Canadian and Hudsonian.

12. FAGACEAE—Oak Family

1. CASTANOPSIS Spach.

1. *Castanopsis chrysophylla* (Dougl.) A. DC. Giant chinquapin.—Common along roadsides and open woodlands of northwest slope. Humid Transition.

13. ARISTOLOCHACEAE—Dutchman's Pipe Family

1. ASARUM L.

1. *Asarum caudatum* Lindl. Wild ginger.—Northwest slope in shaded woods; fairly common. Transition and Canadian.

14. POLYGONACEAE—Buckwheat Family

Stipules wanting; flowers involucrate 1. *Eriogonum*
Stipules present and sheath-like; flowers not involucrate

- Sepals 6, unequal; stigmas tufted2. *Rumex*
 Sepals 5, equal; stigmas capitate3. *Polygonum*

1. ERIOGONUM Michx.

- Calyx stipitate
 Leaves large, 4-8 cm. long, mostly cordate1. *E. compositum*
 Leaves smaller, never cordate2. *E. umbellatum*
 Calyx not stipitate3. *E. nudum*
 1. *Eriogonum compositum* Dougl. Heart-leaved eriogonum.—Dry rocky southeast slope; common. This is a plant of the arid regions of Eastern Oregon. Its occurrence on the west side of the Cascades is an extension of range of considerable interest. Arid Transition.
 2. *Eriogonum umbellatum* Torr. Sulphur-flower.—Very common on summit and on open rocky hillsides of southeast slope. Arid Transition and Hudsonian.
 3. *Eriogonum nudum* Dougl. Naked eriogonum.—Northwest slope along Sharps Creek Road; common. Transition and Upper Sonoran.

2. RUMEX L.

- Plants dioecious; leaves hastate1. *R. Acetosella*
 Plants not dioecious; leaves not hastate
 Margins of inner perianth parts entire2. *R. occidentalis*
 Margins of inner perianth parts with teeth or bristles3. *R. obtusifolius*
 1. *Rumex Acetosella* L. Sour dock.—Common on the Champion Creek-Sharps Creek divide. This is an abundant and widespread weed pest introduced from Europe.
 2. *Rumex occidentalis* Wats. Western dock.—Roadside, south slope, in moist ground. Widely distributed. Boreal and Transition.
 3. *Rumex obtusifolius* L. Broad-leaved dock.—Marsh on the south slope. Introduced from Europe.

3. POLYGONUM L.

- Leaves broad; stems not wiry
 Flowers in a single dense head-like raceme1. *P. bistortoides*
 Flowers not as above
 Flowers few, in axillary raceme or cluster; stems short, spreading3. *P. Newberryi*
 Flowers in terminal panicle; stem tall, erect2. *P. phytolaccaefolium*
 Leaves narrow; stems wiry
 Flowers reflexed in fruit
 Lower leaves obtuse; calyx 3 mm. long; achenes oblong5. *P. Douglasii*
 Lower leaves acute; calyx 2 mm. long; achenes ovoid6. *P. Austiniae*
 Flowers not reflexed in fruit
 Flowers in loose axillary clusters, or if dense, distributed the entire length of the branches; leaves not much reduced upwards
 Leaves oval; flowers 2 or 3 in the axils4. *P. minimum*
 Leaves oblanceolate to obovate; flowers 4 or 5 in the axils8. *P. cascadenae*
 Flowers in close spicate or interrupted terminal racemes, leaves decidedly reduced upwards7. *P. Nuttallii*
 1. *Polygonum bistortoides* Pursh. Bistort.—Quite common on open hillsides of north slope. Hudsonian.
 2. *Polygonum phytolaccaefolium* Meisn. Alpine knotweed.—Roadside on south slope, first switchback on road to lookout; rare. (Powell). Canadian.
 3. *Polygonum Newberryi* Small. Newberry's knotweed.—Moist rocky north slope; common. Hudsonian.
 4. *Polygonum minimum* Wats. Leafy knotweed.—Dry slopes near Musick Mine. Scattered. Hudsonian.
 5. *Polygonum Douglasii* Greene. Douglas' knotweed.—Common about Musick Guard Station and along roadsides. Transition.

6. *Polygonum Austinae* Greene. Austin's knotweed.—Dry open hillside on south slope; not common. The first western Oregon record for this plant which typically is found on sagebrush plains of eastern Oregon. Type locality, Modoc County, California. Arid Transition.

7. *Polygonum Nuttallii* Small. Nuttall's knotweed.—Rocky open hillsides at summit of the mountain. A plant of the Northern element, entering our limits here. To our knowledge, this is its southernmost station thus far reported. Canadian.

8. *Polygonum cascadenae* W. H. Baker. Cascade knotweed.—Rocky south slope and on east slope of adjacent Bohemia Mountain. Known range is from McKenzie Pass to Crater Lake in the Cascades and in the Calapooya Range. Hudsonian.

15. PORTULACACEAE—Purslane Family

Perennial with stem arising from a globose corm1. *Claytonia*
Annual or perennial from a rootstalk or fibrous root2. *Montia*

1. CLAYTONIA (Gron.) L.

1. *Claytonia lanceolata* Pursh. Spring beauty.—Very common in early spring appearing very soon after the snow recedes. It grows on the north slope under Mountain hemlock and in openings on both the north and south slope. It is particularly abundant on the Bohemia-Fairview saddle. Hudsonian.

2. MONTIA L.

Perennials; stem leaves free or nearly so

Stem leaves 2, opposite1. *M. sibirica*
Stem leaves several, alternate2. *M. flagellaris*
Annuals; stem leaves perfoliate3. *M. perfoliata*

1. *Montia sibirica* (L.) Howell. Candy flower.—Fairly common in moist places on northwest slope. Transition.

2. *Montia flagellaris* (Bong.) Robins. Long-branched montia.—Common on rocky northeast slope. This plant is ordinarily a Coast Range plant. A first record for the region. Transition and Canadian.

3. *Montia perfoliata* (Donn.) How. Miner's lettuce.—North slope on moist shaded hillsides; fairly common. Humid Transition.

16. CARYOPHYLLACEAE—Pink Family

Sepals free, or united only at the base

Petals 2-lobed3. *Stellaria*
Petals entire
Stipules present1. *Spergularia*
Stipules none2. *Arenaria*
Sepals united into a tube4. *Silene*

1. SPERGULARIA J. & C. Presl.

1. *Spergularia rubra* (L.) J. & C. Presl. Pink matweed.—Common in dry ground of northwest slope. Introduced from Europe.

2. ARENARIA L.

Leaves narrowly linear, stiff; plants glandular-hairy1. *A. formosa*
Leaves ovate to lanceolate, soft; plants not glandular-hairy2. *A. macrophylla*

1. *Arenaria formosa* Fisch. Slender sandwort.—Rather scarce on Bohemia saddle. It is found on the high peaks of the Cascades and eastward. Hudsonian.

2. *Arenaria macrophylla* Hook. Large-leaved sandwort.—Common in woods of west slope. Transition to Hudsonian.

3. STELLARIA L.

1. *Stellaria crispa* C. & S. Crisped chickweed.—Infrequent on moist shaded hillsides, north slope. Canadian.

4. *SILENE* L.

1. *Silene campanulata* Wats. Bell-shaped catchfly.—Very common at summit. This is a plant of the Southern element and is reported this far north for the first time. It is common in the dry woods of southern Douglas and Josephine counties and southward to California. Transition and Canadian.

17. RANUNCULACEAE—Buttercup Family

Pistils numerous, 1-ovuled; fruit an achene

Stem leaves 3 in a whorl1. *Anemone*

Stem leaves alternate, or none

Leaves simple, palmately lobed2. *Trautvetteria*

Leaves ternately compound3. *Thalictrum*

Pistils few, 2- to many-ovuled; fruit a follicle or a berry

Flowers irregular

Upper sepal spurred at base; petals 44. *Delphinium*

Upper sepal hood-like; petals 25. *Aconitum*

Flowers regular

Petals spurred at base6. *Aquilegia*

Petals not spurred

Leaves simple7. *Caltha*

Leaves compound8. *Actaea*

1. *ANEMONE* L.

Stem leaves simple1. *A. deltoidea*

Stem leaves compound2. *A. Lyallii*

1. *Anemone deltoidea* Hook. Wind-flower.—Very abundant in moist upland woods of northwest slope. Canadian extending into Hudsonian.

2. *Anemone Lyallii* Britt. Lyall's anemone.—Scattered in woods of northwest slope. Canadian.

2. *TRAUTVETTERIA* Fisch. & Mey.

1. *Trautvetteria grandis* Nutt. False bug-bane.—Common in marshy ground at base of St. Peter's Rock near Three Star Mine. Canadian and Hudsonian.

3. *THALICTRUM* L.

1. *Thalictrum occidentale* Gray. Meadow-rue.—Growing in a shady clump of pine on northwest slope, also common along moist roadside thickets of Utopian Way. Canadian and Hudsonian.

4. *DELPHINIUM* L.

1. *Delphinium glareosum* Greene var. *caprorum* (Ewan) com. nov. *D. caprorum* Ewan, Bull. Tor. Bot. Club 69: 145, 1942. Roadside thickets and open hillsides near the summit, also along south slope. Grows on dry rocky ground or moist gravelly slopes; fairly common.

This is apparently an outlying colony as the plant has not been found south of the Three Sisters region which is 60 miles to the northeast. Much variation in form is apparent even within the same colony. Its appearance here constitutes a new locality record outside of the Cascade Mountains. However, there is one record from Mary's Peak in the Coast Range near Corvallis, Oregon. Typical *D. glareosum* is a local species limited to the Olympic Mountains, the var. *caprorum* has a more wideranging distribution in the Cascades of Oregon and Washington. Canadian to Hudsonian.

5. *ACONITUM* L.

1. *Aconitum Howelli* A. Nels. Aconite.—Common around marshes and springs. Bulb-bearing in the leaf axils. Canadian.

6. AQUILEGIA L.

1. *Aquilegia formosa* Fisch. Columbine.—Growing on north slope near edge of melting snow. Widely distributed in wet places. Transition to Hudsonian.

7. CALTHA L.

1. *Caltha biflora* DC. White marsh marigold.—A common marsh plant growing near Musick Mine. Hudsonian.

8. ACTAEA L.

1. *Actaea arguta* Nutt. Western baneberry.—Shady northwest slope; not common. Humid Transition to Canadian.

18. BERBERIDACEAE—Barberry Family

Shrubs; leaves evergreen, spiny 1. *Berberis*
Herbs; leaves not as above 2. *Achlys*
Leaflets 3; flowers in a spike 3. *Vancouveria*
Leaflets many; flowers in a raceme or panicle

1. BERBERIS L.

1. *Berberis nervosa* Pursh. Mountain Oregon grape.—Open woods of west slope; fairly common. Humid Transition.

2. ACHLYS DC.

1. *Achlys triphylla* (Sm.) DC. Vanilla-leaf.—Abundant in shaded rocky soil of northwest slope, reaching to 5,600 ft. Humid Transition but reaches its upper limits in the Hudsonian.

3. VANCOUVERIA MORT. & DEC.

1. *Vancouveria hexandra* (Hook.) Mort. & Dec. Inside-out flower.—Shaded woods northwest slope; common. Humid Transition and Canadian.

19. FUMARIACEAE—Bleeding-heart Family

1. DICENTRA Bernh.

1. *Dicentra formosa* (Andr.) Walp. Bleeding heart.—Fairly common in moist woods and along road to summit of the mountain. Humid Transition.

20. CRUCIFERAE—Mustard Family

Pod short, flattened, a silicle 1. *Thlaspi*
Pod much longer than broad, a silique 2. *Brassica*
Flowers yellow, cream colored, or orange
Some of the leaves deeply cleft or pinnately lobed
Pods with a distinct beak 3. *Rorippa*
Pods beakless 4. *Barbarea*
Valves of the pods nerveless 5. *Ersimum*
Valves of the pods nerved 6. *Dentaria*
All the leaves entire or merely toothed 7. *A. abis*
Flowers white, pink or purple
Stem arising from a tuberous rootstalk 7. *A. abis*
Stem not from a rootstalk

1. THLASPI L.

1. *Thlaspi alpestre* L. Perennial penny-cress.—Common on open north and northwest slopes, growing among rocks. Hudsonian.

2. BRASSICA L.

Stem leaves clasping 1. *B. campestris*
Stem leaves not clasping 2. *B. Kaber*
1. *Brassica campestris* L. Yellow mustard.—Musick Guard Station; not common. Introduced from Europe.

2. *Brassica Kaber* (DC.) L. C. Wheeler. Charlock.—Musick Guard Station; not common. Introduced from Europe.—*B. arvensis* (L.) Rabenh.

3. RORIPPA Scop.

1. *Rorippa curvisiliqua* (Hook.) Bessey. Yellow cress.—Marshy ground around Musick Mine; quite common. Upper Sonoran and Transition.—*Radicula curvisiliqua* (Hook.) Greene.

4. BARBARAEA R. Br.

1. *Barbaraea orthoceras* Ledeb. Winter cress.—Along Sharps Creek Road and in a marsh at Musick Mine; fairly common. Upper Sonoran and Transition.

5. ERYSIMUM L.

1. *Erysimum capitatum* (Dougl.) Greene. Orange wallflower.—Growing along trail on northwest slope; common. Upper Sonoran and Transition.

6. DENTARIA L.

1. *Dentaria tenella* Pursh var. *pulcherrima* (Greene) Detl. Large toothwort.—North slope at very edge of snow line; common. Humid Transition.

7. ARABIS L.

1. *Arabis Drummondii* Gray. Drummond's rock cress.—Scattered along west slope near Utopian Way. Canadian and Hudsonian.

21. CRASSULACEAE—Stone-crop Family

1. SEDUM L.

Petals distinct to base

Leaves spatulate, glaucous1. *S. spathulifolium*

Leaves not spatulate, not glaucous2. *S. Douglasii*

Petals united below3. *S. oregonense*

1. *Sedum spathulifolium* Hook. Broad-leaved stone-crop.—Common on rocks of south-east slope. Transition.

2. *Sedum Douglasii* Hook. Douglas' stone-crop.—Rather rare at summit. Transition and Canadian.

3. *Sedum oregonense* (Wats.) Peck. Creamy stone-crop.—Growing on dry rocky outcroppings on north slope; common. Hudsonian.—*Cotyledon oregonensis* Wats; *Gormanii Watsoni* Britt.

22. SAXFRAGACEAE—Saxifrage Family

Herbs

Stamens 5 or fewer

Stamens 3 or 2; petals 4, linear; flowers purple1. *Tolmiea*

Stamens 5

Petals cleft, lobed or toothed2. *Mitella*

Petals entire

Placentae axial3. *Boykinia*

Placentae parietal or nearly basal4. *Heuchera*

Stamens 10

Placentae axial; ovary 2-loculed5. *Saxifraga*

Placentae parietal; ovary 1-loculed

Petals cleft, lobed or toothed

Petals white or pink, clawed; styles normally 36. *Lithophragma*

Petals becoming red, sessile; styles normally 27. *Tellima*

Petals entire, almost linear8. *Tiarella*

Shrubs

Leaves opposite

Plant low, spreading or trailing9. *Whipplea*

- Plant erect, 1 to 3 m. tall 10. *Philadelphus*
 Leaves alternate 11. *Ribes*

1. *TOLMIEA* T. & G.

1. *Tolmiea Menziesii* (Pursh) T. & G. Youth-on-age.—Growing about a spring on Utopian Way, abundant in moist places and along streams. Humid Transition.

2. *MITELLA* L.

- Petals white, 3-cleft at apex 1. *M. trifida*
 Petals green, pinnately cleft into narrowly-linear divisions 3. *M. ovalis*
 Leaves oblong to ovate, with scattered white hairs 2. *M. Breweri*
 Leaves round-cordate, mainly glabrous

1. *Mitella trifida* Graham. Three-toothed bishop's cap.—Rocky soil at summit east of the old lookout; common. Hudsonian.

2. *Mitella Breweri* Gray. Brewer's bishop's cap.—Moist slope at high altitudes north side of the mountain; quite common. Upper Canadian and Hudsonian.

3. *Mitella ovalis* Greene. Small bishop's cap.—Common in wet places around springs on west side. Humid Transition.

3. *BOYKINIA* Nutt.

- Stipules reduced to bristles 1. *B. elata*
 Stipules scarious or leaf-like 2. *B. major*

1. *Boykinia elata* (Nutt.) Greene. Slender boykinia.—Fairly common in wet places around springs and along stream banks. Humid Transition.

2. *Boykinia major* Gray. Large boykinia.—Rather local, growing in marshy ground near the Three Star Mine at the base of St. Peter's Rock. Humid Transition.

4. *HEUCHERA* L.

1. *Heuchera micrantha* Dougl. var. *glaberrima* (Rydb.) com. nov. *H. g'aberrima* Rydb. in N. Amer. Fl. 22: 103. 1905.—North slope, rock cliff just below the lookout tower. This is the glabrous variety which is very common in the Cascades of northern Oregon and in the Columbia Gorge. Humid Transition to Hudsonian.

5. *SAXIFRAGA* L.

- Low tufted plants with perennial branches, densely covered with small leaves; flowers orange spotted 1. *S. bronchialis*
 Plants not tufted, not as above

- Leaves all basal 2. *S. rufidula*
 Leaves not all basal

- Plants with roundish leaves, usually doubly toothed 3. *S. Mertensiana*
 Plants with spatulate leaves, toothed above the middle 4. *S. ferruginea*

1. *Saxifraga bronchialis* L. var. *vespertina* (Small) Piper. Matted saxifrage.—At high altitudes on rocks of northwest slope at the base of a cliff; not common. Hudsonian.

2. *Saxifraga rufidula* (Small) Macoun. Red-woolly saxifrage.—Moist rocky north slope; not common. Hudsonian.

3. *Saxifraga Mertensiana* Bong. Merten's saxifrage.—North slope growing on wet cliffs; common. Hudsonian.

4. *Saxifraga ferruginea* Graham. Rusty saxifrage.—Very common growing in moist ground on the northwest slope. Hudsonian.

6. *LITHOPHRAGMA* Nutt.

1. *Lithophragma parviflorum* (Hook.) Nutt. Ragged star-flower.—Open grassy hillside on the south slope; common in the early spring. Transition.

7. TELLIMA R. Br.

1. *Tellima grandiflora* (Pursh) Dougl. Fringe-cups.—Fairly common northwest slope. Humid Transition.

8. TIARELLA L.

Leaves simple, toothed 1. *T. unifoliata*
Leaves compound, 3 leaflets 2. *T. trifoliata*

1. *Tiarella unifoliata* Hook. Cool-wort.—Common in moist woods at the juncture of the Sharps Creek Road and the Utopian Way. Canadian.

2. *Tiarella trifoliata* L. Three-leaved cool-wort.—Common in woods at lower elevations. Humid Transition.

9. WHIPPLEA Torr.

1. *Whipplea modesta* Torr. Whipple-vine.—Common in open woods along Sharps Creek Road. Humid Transition.

10. PHILADELPHUS L.

1. *Philadelphus Lewisii* Pursh. Mock orange.—Occurs on south slope; infrequent. This form grows east of the Cascade mountains. It is reported from this area for the first time. Humid Transition to Canadian.

11. RIBES L.

Stems without spines or prickles

Flowers bell-shaped, pink or red, showy 1. *R. sanguineum*
Flowers saucer-shaped, greenish, inconspicuous 2. *R. bracteosum*

Stems with spines and sometimes prickles

Calyx spreading or saucer-shaped; berry with gland-tipped hairs 3. *R. lacustre*
Calyx bell-shaped or cylindrical; berry with sharp, unequal prickles 4. *R. binominatum*

1. *Ribes sanguineum* Pursh. Red-flowering currant.—Infrequent along west slope near Sharps Creek Road. Humid Transition.

2. *Ribes bracteosum* Dougl. Stinking black currant.—South bank of City Creek at base of Fairview Mountain; not common. Humid Transition and Canadian.

3. *Ribes lacustre* (Pers.) Poir. Swamp currant.—Common on north slope where it is the main undercover. Hudsonian.

4. *Ribes binominatum* Heller. Siskiyou gooseberry.—Scattered along roadside below the summit. This station is the first record of the plant from Lane County. It has been reported previously from southern Douglas County. This species is a representative of the Southern element in our flora. Canadian.

23. ROSACEAE—Rose Family

Shrubs or trees

Fruits enclosed in an urn-shaped, globose receptacle 1. *Rosa*

Fruits not enclosed as above

Ovary inferior; fruit a pome

Fruits blue-black; leaves simple; flowers in racemes 2. *Amelanchier*

Fruits red; leaves compound; flowers in corymbs 3. *Sorbus*

Ovary not inferior

Pistil 1 4. *Prunus*

Pistil more than 1

Fruit dry, a follicle 5. *Holodiscus*

Fruit fleshy, of aggregate drupelets 6. *Rubus*

Herbs

Flowers very small, borne in plume-like panicles, plants dioecious 7. *Aruncus*

Flowers larger, not borne in plume-like panicles, usually perfect

Flowers white; fruit fleshy 8. *Fragaria*

Flowers yellow; fruit dry 9. *Potentilla*

1. ROSA L.

1. *Rosa gymnocarpa* Nutt. Wood rose.—Scattered throughout woods of the northwest slope at lower elevations. Transition and Canadian.

2. AMELANCHIER Medic.

1. *Amelanchier florida* Lindl. Service berry.—Roadside northwest slope; not common. Humid Transition. Occasional plants found above 5,000 feet.

3. SORBUS (Tourn.) L.

Leaves toothed almost the entire length 1. *S. cascadiensis*
Leaves toothed above the middle or near the apex 2. *S. occidentalis*

1. *Sorbus cascadiensis* G. N. Jones. Mountain ash.—Occasional on west slope. Mainly Canadian but sometimes approaches to lower Hudsonian on warm open slopes.—*S. sitchensis* Roem; *Pyrus sitchensis* (Roem.) Piper of some authors.

2. *Sorbus occidentalis* (Wats.) Greene. Small mountain ash.—Common on north slope near summit. This is a shrub of the higher elevations. Hudsonian.

4. PRUNUS L.

1. *Prunus emarginata* (Dougl.) Walp. Wild cherry.—Growing on the north slope. A shrub forming dense thickets on open hillsides. The leaves, twigs and inflorescences are quite glabrous which is characteristic of this species. This constitutes the first record of the plant west of the Cascades in Oregon, the common form here being *P. emarginata* var. *erecta* which has the leaves thin and tomentose on the under surface, and takes the form of a small tree instead of a shrub. Hudsonian.

5. HOLODISCUS Maxim.

Plant erect; leaves minutely hairy beneath 1. *H. discolor*
Plant diffuse; leaves glandular-dotted beneath 2. *H. glabrescens*

1. *Holodiscus discolor* (Pursh) Maxim. Ocean spray.—Fairly common on south slope along Sharps Creek Road. Transition.

2. *Holodiscus glabrescens* (Greenm.) Hel. Dwarf ocean spray.—Rather scarce on east slope near summit. Entering our area from the drier regions to the east. Not previously reported from the area west of the Cascades. Boreal.

6. RUBUS L.

Stems creeping or trailing

Stems unarmed, not prickly

Leaves compound, with 3 to 5 leaflets 1. *R. pedatus*

Leaves merely 3 to 5 lobed 2. *R. lasiococcus*

Stems prickly 3. *R. vitifolius*

Stem erect

Flowers red, rarely pinkish; fruit yellowish orange, rarely dark red 4. *R. spectabilis*

Flowers white

Leaves simple, palmately lobed; fruit red 5. *R. parviflorus*

Leaves compound-pinnate; fruit black 6. *R. leucode mis*

1. *Rubus pedatus* Smith. Trailing raspberry.—Very common on northwest slope. It grows with *R. lasiococcus* here, from which it differs by the presence of compound leaves, 3 to 5 leaflets, and glabrous fruit. Open woods of the Canadian and Hudsonian.

2. *Rubus lasiococcus* Gray.—Common, growing with *R. pedatus*. Northwest slope, open woods in shady humus soil. Canadian and Hudsonian.

3. *Rubus vitifolius* C. & S. Wild blackberry.—West slope near an old mine shaft on Utopian Way; rather uncommon. Humid Transition.

4. *Rubus spectabilis* Pursh. Salmon-berry.—A shrub of lower elevations along the roadside; not common. Humid Transition.

5. *Rubus parviflorus* Nutt. Thimbleberry.—Uncommon. Summit of the mountain.

This was a dwarfed specimen, the plant being only about 3 dc. tall. Transition, extending into Hudsonian.

6. *Rubus leucodermis* Dougl. Western blackcap.—Common in open woods of north slope. Transition.

7. ARUNCUS L.

1. *Aruncus sylvester* Kost. Goats beard.—Fairly common on shady north slope. Transition.

8. FRAGARIA L.

1. *Fragaria bracteata* Heller. Wood strawberry.—Common in moist woods. West slope along Utopian Way. Transition.

9. POTENTILLA L.

Leaves palmately compound; leaflets all from the summit of the petiole 1. *P. gracilis*
Leaves pinnate; leaflets more or less scattered on an elongated rachis

Leaflets ovate, simply toothed 2. *P. glandulosa*

Leaflets deeply cleft or incised

Herbage green 3. *P. Drummondii*

Herbage silvery 4. *P. Breweri*

1. *Potentilla gracilis* Dougl. Five-finger.—Rather abundant on warm south slope. Humid Transition.

2. *Potentilla glandulosa* Lindl. Sticky cinquefoil.—Growing in rocky soil of south slope near summit; fairly common. Canadian.

3. *Potentilla Drummondii* Lehm. Drummond's cinquefoil.—Common in yard of Muck Mine property. Hudsonian.

4. *Potentilla Breweri* Wats. Brewer's cinquefoil.—Grows in marshes on north side. Canadian.

24. LEGUMINOSAE—Pea Family

Leaves palmately compound

Leaflets 5 or more, entire 1. *Lupinus*

Leaflets 3 (ours), not entire 2. *Trifolium*

Leaves pinnately compound

Tendrils none 3. *Lotus*

Tendrils usually present

Style filiform, ending in a hairy, capitate stigma 4. *Vicia*

Style flattened, hairy only on the upper surface 5. *Lathyrus*

1. LUPINUS (Tourn.) L.

Plants short, low; herbage silky 1. *L. aridus*

Plants tall, erect; herbage green, pubescence thin or glabrous, sometimes silvery villous

Lower leaves long petioled at flowering time; stem suffrutescent at the base

..... 2. *L. albispirans*

Lower leaves not long petioled; stem not suffrutescent

Keel more or less ciliate on the upper margins; stem simple 3. *L. latifolius*

Keel not ciliate; stem branched

Keel bent upwards and long exserted; banner acute at the apex 4. *L. albicaulis*

Keel little bent and hardly at all exserted; banner obtuse at the apex

..... 5. *L. Andersonii*

1. *Lupinus aridus* Dougl. var. *Torreyi* (Gray) C. P. Sm. Torrey's lupine.—Fairly common, dry ground, southwest slope. This form is the one most common on the east slope of the Cascades from Sun Pass throughout western Klamath County. Upper Sonoran and Transition.

5. *Lupinus Andersonii* Wats. Anderson's lupine.—Common along northwest slope in humid soil. Reaches its northern limit in southern Lane County. Arid Transition and Canadian.

3. *Lupinus latifolius* Agardh. var. *subalpinus* (Pip. & Rob.) C. P. Sm. Alpine lupine.—Growing along Sharps Creek Road; not common. Hudsonian.

4. *Lupinus albicaulis* Dougl. White-stemmed lupine.—Shady banks and open woods on north slope; common. Humid Transition.

2. *Lupinus albifrons* Benth var. *flumineus* C. P. Sm. White-leaved lupine.—Dry open hillside on west slope below the Fairview lookout tower; infrequent. Arid Transition.

2. TRIFOLIUM L.

Stems creeping, rooting at the nodes 1. *T. repens*
Stems not creeping, not rooting at the nodes

Rachis of the head prolonged beyond the flowers 3. *T. Kingii*

Rachis bearing flowers to the apex, not prolonged 2. *T. Howellii*

1. *Trifolium repens* L. White clover.—Very common. Introduced from Europe.

2. *Trifolium Howellii* Wats. Howell's clover.—Common on both north and west slopes, in marshes and along roadsides. A northern extension of the range of this plant. Reported previously from moist slopes in mountain woods only as far north as Jackson and Josephine counties. Humid Transition.

3. *Trifolium Kingii* Wats. King's clover.—On an open ridge in the woods, Bohemia-Fairview saddle; scattered. Not previously reported this far north. Applegate (1939: 279) lists it from Crater Lake National Park. It has been collected also in the southern Siskiyou and in the Warner Mountains of Lake County. This is the first record west of the Cascades in Lane County. Canadian.

3. LOTUS L.

1. *Lotus crassifolius* (Benth.) Greene. Pink trefoil.—Northwest slope, in rocky soil; not common. Arid Transition.

4. VICIA L.

Leaves thin; pods puberulent 1. *V. californica*

Leaves firm; pods glabrous 2. *V. americana*

1. *Vicia californica* Greene. California vetch.—West slope, in open woods; occasional. A common plant in the southern counties of Oregon. Transition.

2. *Vicia americana* Muhl. American vetch.—West slope, edge of woods; common. Transition.

a. *Vicia americana* Muhl. var. *truncata* (Nutt.) Brew.—Marsh on north side of mountain; not uncommon. Transition.

5. LATHYRUS L.

Flowers purple 2. *L. Nuttallii*

Flowers white or ochroleucus 1. *L. nevadensis*

1. *Lathyrus nevadensis* Wats. Nevada pea.—Growing on west slope along roadside; not common. Transition.

2. *Lathyrus Nuttallii* Wats. Nuttall's pea.—West slope; fairly common. Transition.

25. LINACEAE—Flax Family

1. LINUM L.

1. *Linum Lewisii* Pursh. Blue flax.—North slope, rocky soil on open hillside; common. A characteristic species from the arid regions to the east. It has not previously been reported from as far north as Lane County in western Oregon, although it grows in the Siskiyou Mountains and in southern Jackson County.

26. OXALIDACEAE—Oxalis Family

1. OXALIS L.

1. *Oxalis oregana* Nutt. Wood sorrel.—Very common, forming ground cover on forest floor of northwest slope. Humid Transition to Canadian.

27. CELASTRACEAE—Burning Bush Family

1. PACHISTIMA Raf.

1. *Pachistima Myrsinites* (Pursh) Raf. Oregon boxwood.—Not uncommon along Sharps Creek Road. Transition to Hudsonian.

28. ACERACEAE—Maple Family

1. ACER L.

- Leaves large, 1-3 dm. broad; flowers borne in racemes; fruit hispid on the body 1. *A. macrophyllum*
 Leaves small, 4-7 cm. broad, flowers borne in corymbs; fruit glabrous 2. *A. circinatum*
 Leaves 7 to 9 lobed; wings of fruit spreading at right angles to the stalk 3. *A. Douglasii*
 Leaves 3 to 5 lobed; wings of fruit ascending 1. *Acer macrophyllum* Pursh. Large-leaved maple.—North slope for a short distance up Crystal Creek; not common. Humid Transition.
 2. *Acer circinatum* Pursh. Vine maple.—Moist woods near base of northeast slope; common. Humid Transition to Canadian.
 3. *Acer Douglasii* Hook. Dwarf maple.—Rather infrequent in rocky soil of north slope. Upper Canadian.

29. HYPERICACEAE—St. John's Wort Family

1. HYPERICUM L.

- Low annual, forming mats; flowers minute, 6 mm. wide 1. *H. anagalloides*
 Tall perennial, erect; flowers large, 20 mm. wide 2. *H. perforatum*
 1. *Hypericum anagalloides* C. and S. Water. St. John's Wort.—Common marsh plant of north side of mountain. Transition to Hudsonian.
 2. *Hypericum perforatum* L. St. John's Wort.—Very abundant on Bohemia saddle. Naturalized from Europe and a very troublesome weed in some sections.

30. VIOLACEAE—Violet Family

1. VIOLA L.

- Stem creeping and prostrate; leaves evergreen 1. *V. sempervirens*
 Stem not creeping, erect; leaves not evergreen 2. *V. Sheltonii*
 Leaves deeply dissected into narrow segments 3. *V. glabella*
 Leaves not dissected, merely serrate or crenate 1. *Viola sempervirens* Greene. Evergreen violet.—Open woods on west and north slopes; fairly common. Humid Transition.
 2. *Viola Sheltonii* Torr. Shelton's violet.—Dry rocky ground on Bohemia-Fairview saddle, also in similar situations on North Fairview saddle. This violet is quite common early in the spring just after the snow melts. Canadian.
 3. *Viola glabella* Nutt. Wood violet.—Common on wooded slope east side of the mountain, and along Utopian Way. Canadian.

31. ONAGRACEAE—Evening Primrose Family

- Parts of the flower in 4's; fruit a capsule 1. *Epilobium*
 Seeds with a tuft of hairs at one end 3. *Gayophytum*
 Seeds without tuft of hairs 2. *Godeetia*
 Calyx tube absent; flowers small 4. *Circaea*
 Calyx tube present; flowers showy 1. *E. angustifolium*
 Parts of the flower in 2's; fruit bur-like 2. *E. paniculatum*

1. EPILOBIUM L.

- Flowers showy; petals spreading, 15-18 mm. long, entire 1. *E. angustifolium*
 Flowers small; petals not spreading, 3-10 mm. long, cleft 2. *E. paniculatum*
 Annuals; stigma 4-cleft
 Perennials; stigma entire

Mostly low elevation plants, about springs and watercourses, 3 to 9 dm. or more tall 3. *E. adenocaulon*

Mostly high mountain plants, less than 3 dm. tall

Stem simple but tufted; flowers nodding 4. *E. alpinum*

Stem only one from the base; flowers not nodding 5. *E. Hornemannii*

1. *Epilobium angustifolium* L. Fireweed.—Open hillsides of north slope; common. Transition to Hudsonian.

2. *Epilobium paniculatum* Nutt. Tall willow herb.—Common in open woods of west slope and along Utopian Way. Transition.

3. *Epilobium adenocaulon* Hausskn. Common willow herb.—Wet ground along Utopian Way and at Musick Mine; very common. Transition.

4. *Epilobium alpinum* L. Alpine willow herb.—Very common at high altitudes on north slope. Hudsonian.

5. *Epilobium Hornemannii* Reichenb. Hornemann's willow herb.—Common at high elevations on north slope and in shady places along west slope. Hudsonian.

2. GODETIA Spach.

1. *Godezia amoena* (Lehm.) G. Don. Wild Godetia.—Growing on a rock slide along Utopian Way; not common. Humid Transition.

3. GAYOPHYTUM Juss.

Seeds glabrous 1. *G. diffusum*

Seeds minutely appressed-pubescent 2. *G. lasiospermum*

1. *Gayophytum diffusum* T. and G. Spreading gayophytum.—Northwest side of mountain and around Musick Mine on the south side; fairly common. A plant of the dry arid regions east of the Cascades. This is an extension of range. Transition.

2. *Gayophytum lasiospermum* Greene var. *Hoffmanii* Munz.—Hair-seeded gayophytum. South and west slope on dry ground; scattered. It overlaps with the previous species and like it is a representative of the Eastern element in our flora. This is a new locality for the plant. Transition.

4. CIRCAEA L.

1. *Circaea pacifica* Asch. & Magn. Enchanter's nightshade.—Moist shady woods of west slope; fairly common. Transition.

32. UMBELLIFERAE—Parsley Family

Fruits linear, several times as long as wide 1. *Osmorhiza*

Fruits oblong or roundish

Fruits with hooked bristles 2. *Sanicula*

Fruits smooth, not as above

Flowers yellow (ours) 3. *Lomatium*

Flowers white, pinkish or purple

Low plants, usually under 15 cm. tall 6. *Orogenia*

Plants 6 dm. or more in height, (often much taller)

Fruits winged

Plants 1 to 2 m. tall; flowers white 4. *Heracleum*

Plants smaller, usually under 1 m. tall; flowers (of ours) purple 5. *Lepictenia*

Fruits not winged 7. *Ligusticum*

1. OSMORHIZA Raf.

Fruit bristly on the ribs 1. *O. chilensis*

Fruit glabrous 2. *O. occidentalis*

1. *Osmorhiza chilensis* Hook. & Arn. Common sweet cicely.—Common on north slope. Canadian.—*O. nuda* Torr.; *O. divaricata* Nutt.

2. *Osmorhiza occidentalis* Torr. Western sweet cicely.—On north slope and summit; common. Grows with *O. chilensis* but extends to higher altitudes. Canadian to Hudsonian.

2. SANICULA L.

1. *Sanicula septentrionalis* Greene. Snake-root.—Local on summit, dry rocky ground. Canadian.

3. LOMATIUM Raf.

Mature fruit about 15 mm. long 1. *L. Martindalei*
Mature fruit about 6 mm. long 2. *L. Hallii*

1. *Lomatium Martindalei* C. & R. Martindale's hog fennel.—Summit of mountain and on rock slides of north slope. Grows in the same habitat as *L. Hallii* at summit. Hudsonian.

2. *Lomatium Hallii* (Wats.) C. & R. Hall's hog fennel.—Not uncommon but rather restricted to summit of the mountain and for a short distance down hillside of east slope. Canadian.

4. HERACLEUM L.

1. *Heracleum maximum* Bartr. Cow parsnip.—Utopian Way and in moist situations or in mountain marshes; not uncommon. Hudsonian.—*H. lanatum* Michx.

5. LEPTOTAENIA Nutt.

1. *Leptotaenia dissecta* Nutt. Lace-leaved Leptotaenia.—Summit of mountain, on dry rocky ground; common. Canadian and Hudsonian.

6. OROGENIA Wats.

1. *Orogenia fusiformis* Wats. Mountain orogenia.—On south slope, Bohemia-Fairview saddle, also on north slope, North Fairview saddle; common in early spring. Canadian.

7. LIGUSTICUM L.

1. *Ligusticum apiifolium* (Nutt.) Gray. Celery-leaved lovage.—Open gravelly soil of north slope; common. Humid Transition.

33. GARRYACEAE—Silk Tassel Family

1. GARRYA Dougl.

1. *Garrya Fremontii* Torr. Bear brush.—Scattered along Utopian Way and on north-west slope at occasional stations. Transition.

34. CORNACEAE—Dogwood Family

1. CORNUS L.

1. *Cornus canadensis* L. Bunch-berry.—Open woods of northeast slope; fairly common. Canadian.

35. ERICACEAE—Heath Family

Ovary superior

Herbs (sometimes shrubby at base)

Plants with green leaves

Flowers in corymbs or umbels; filaments dilated at or below the middle

..... 1. *Chimaphila*

Flowers in racemes; filaments not dilated 2. *Pyrola*

Plants without green leaves 3. *Hylopetes*

Shrubs

Flowers large, very showy, over 2 cm. 4. *Rhododendron*

Flowers small, under 1 cm.

Calyx becoming enlarged and fleshy; bark not reddish 5. *Gaultheria*

Calyx small and dry; bark red 6. *Arctostaphylos*

Ovary inferior 7. *Vaccinium*

1. CHIMAPHILA Pursh

- Leaves wider above the middle 1. *C. umbellata*
 Leaves wider below the middle 2. *C. Menziesii*

1. *Chimaphila umbellata* (L.) Nutt. Prince's pine.—In woods of northwest and western slopes; common. Canadian.

2. *Chimaphila Menziesii* (R. Br.) Spreng. Menzies' prince's pine.—Common on wet slope. Canadian.

2. PYROLA L.

- Style straight, erect; flowers in a one-sided raceme 1. *P. secunda*
 Style curved downward; flowers not as above

Leaves green throughout, orbicular 2. *P. bracteata*

Leaves white-veined, elliptic to ovate 3. *P. picta*

1. *Pyrola secunda* L. One-sided wintergreen.—Very common in dense shade east side of Utopian Way, and scattered along north slope. Canadian.

2. *Pyrola bracteata* Hook. Leathery shin-leaf.—Common in shady woods of north slope along Utopian Way. Canadian.

3. *Pyrola picta* Smith. White-veined shin-leaf.—Scattered stations on northeast slope, also growing on west slope trail. Canadian.

3. HYPOPHYTIS Hill

1. *Hypophytis fimbriata* (Gray) Howell. Fringed pine-sap.—In coniferous woods at base of mountains; rather rare. Canadian.

4. RHODODENDRON L.

1. *Rhododendron macrophyllum* G. Don. Rhododendron.—A common shrub on hill-sides of western slope and along Utopian Way. Principally Humid Transition but reaching above 5,000 feet in higher mountains of the Cascades.

5. GAULTHERIA L.

- Leaves 3 cm. or less long; fruit scarlet 1. *G. ovatifolia*
 Leaves 5 to 12 cm. long; fruit black 2. *G. Shallon*

1. *Gaultheria ovatifolia* Gray. Slender gaultheria.—Moist open woods on west slope; fairly common. Canadian.

2. *Gaultheria Shallon* Pursh. Salal.—Shaded woods of north side of the mountain; common. Humid Transition.

6. ARCTOSTAPHYLOS Adans

1. *Arctostaphylos nevadensis* Gray. Pine-mat manzanita.—Forming dense mats along Sharps Creek Road; fairly common. Hudsonian.

7. VACCINIUM L.

Tall shrubs, 1 to several m.

Leaves entire, except sometimes in young growth

Berry red 1. *V. parvifolium*

Berry blue-black 2. *V. ovalifolium*

Leaves toothed 3. *V. membranaceum*

Low shrubs, rarely more than 1 or 2 dm. 4. *V. scoparium*

1. *Vaccinium parvifolium* Sm. Red huckleberry.—On north side near base of mountain; fairly common. Humid Transition.

2. *Vaccinium ovalifolium* Sm. Tall blue huckleberry.—Woods of north slope; very common. Canadian.

3. *Vaccinium membranaceum* Dougl. Mountain huckleberry.—North slope in humid rocky soil; very abundant. Widely distributed in this area and much prized for its fruit. Canadian.

4. *Vaccinium scoparium* Leiberg. Small red huckleberry.—Middle altitudes on north side of mountain; common. Canadian.

36. PRIMULACEAE—Primrose Family

1. TRIENTALIS L.

1. *Trientalis latifolia* Hook. Starflower.—Woods of west slope; very common. Humid Transition and Canadian.

37. GENTIANACEAE—Gentian Family

1. GENTIANA L.

1. *Gentiana calycosa* Griseb. Blue gentian.—Subalpine meadows and shaded rocky soil of moist north slope; common. Hudsonian.

38. APOCYNACEAE—Dogbane Family

1. APOCYNUM (Tourn.) L.

Corolla tube about 3 times the length of calyx1. *A. androsaemifolium*
Corolla tube about twice the length of calyx2. *A. medium*

1. *Apocynum androsaemifolium* L. Dogbane.—South slope along Musick Mine Road; not common. Transition.

2. *Apocynum medium* Greene var. *vestitum* (Greene) Woodson.—Intermediate dogbane. South slope; not common. This variety, though reported from southern Jackson and Josephine counties, has not previously been reported from Lane County. Upper Sonoran and Transition.

39. POLEMONIACEAE—Phlox Family

Leaves alternate, pinnately compound, leaflets entire; corolla campanulate1. *Polemonium*
Leaves simple, often finely cut or deeply lobed, sometimes entire; corolla various

Calyx not ruptured by the growing capsule6. *Collomia*

Calyx ruptured by the growing capsule

Corolla salverform, contracted at throat2. *Phlox*

Corolla tubular, funnelform, or sometimes salverform, throat not contracted

Calyx lobes unequal, sharp-pointed5. *Navaretia*

Calyx lobes equal, rarely sharp-pointed

Perennials or biennials; leaves compound or pinnately cleft3. *Gilia*

Annuals; leaves simple, entire4. *Microsteris*

1. POLEMONIUM L.

1. *Polemonium carneum* Gray. Jacob's ladder.—At summit of mountain, growing among rocks and on rock shelves of north side. Canadian to Hudsonian.

2. PHLOX L.

1. *Phlox diffusa* Benth. var. *longistylis* Wherry. Mountain phlox.—North slope in rocky soil; fairly common. Hudsonian.

3. GILIA R. and P.

Stems woody at base3. *G. Nuttallii*
Stems herbaceous

Corolla blue; inflorescence dense, head-like1. *G. capitata*

Corolla scarlet, rarely pinkish or white, never blue; inflorescence open2. *G. aggregata*

1. *Gilia capitata* Sims. Field gilly-flower.—On road leading to summit, and on south and southwest slopes, growing with *G. aggregata*. Transition to Canadian.

2. *Gilia aggregata* (Pursh) Spreng. Scarlet gilia.—Very common on south and southwest slopes. This is one of the most strikingly beautiful plants found on the mountain. It is common east of the Cascades, but is here recorded for the first time in our region. Canadian.

3. *Gilia Nuttallii* Gray. Nuttall's gilia.—Rocky soil of north slope, and along Musick

Mine road on south slope; common. A common plant of the Blue and Steen Mountains of eastern Oregon. This is an interesting extension of range into western Oregon. Hudsonian

4. MICROSTERIS Greene

Corolla 9 to 12 mm. long1. *M. gracilis*
Corolla under 7 mm. long2. *M. humilis*

1. *Microsteris gracilis* (Dougl.) Greene. Pink microsteris.—Dry soil, Bohemia saddle, Utopian Way, and on road to summit. Transition.

2. *Microsteris humilis* (Dougl.) Greene. Low microsteris.—Dry hillsides on south slope near Musick Mine; not common. Transition.

5. NAVARRETIA Ruiz. & Pav.

1. *Navaretia divaricata* (Torr.) Greene. Short-stemmed navaretia.—Dry hillside along the road to the summit, south slope, local. This plant has not been previously reported from west of the Cascade Mountains. It is reported by Peck (1941: 581) from Wallowa and Wheeler counties in Oregon and by Applegate (1939: 293) from Crater Lake National Park. Canadian.

6. COLLOMIA Nutt.

Leaves, at least the lower ones, not entire1. *C. heterophylla*
Leaves entire

Corolla pink, about 1 cm. long3. *C. aristella*
Corolla salmon-colored, 1.5 to 3 cm. long2. *C. grandiflora*

1. *Collomia heterophylla* Hook. Vari-leaved collomia.—Growing in open woods along Utopian Way; fairly common. Humid Transition.

2. *Collomia grandiflora* Dougl. Large-flowered collomia.—Local situations on south slope of Fairview Mountain near Bohemia saddle, open dry hillside. Transition.

3. *Collomia aristella* (Gray) Rydb. Bristle-tipped collomia.—Roadsides and open woods, south and southwest slopes; occasional. Canadian.

40. HYDROPHYLLACEAE—Water-leaf Family

Style entire4. *Romanzoffia*
Style 2-cleft

Flowers solitary in the leaf axils2. *Nemophila*

Flowers in head-like or scorpioid cymes, not as above

Flowers in head-like clusters1. *Hydrophyllum*
Flowers in scorpioid cymes3. *Phacelia*

1. HYDROPHYLLUM Tourn.

Inflorescence more or less open; flowers generally white; leaf lobes acute at the apex

.....1. *H. Fendleri*
Inflorescence congested; flowers blue; leaf lobes obtuse at the apex2. *H. occidentale*

1. *Hydrophyllum Fendleri* (Gray) Heller var. *albifrons* (Gray) Macbr. White water-leaf.—Moist soil on north slope; fairly common. Arid Transition and Canadian.

2. *Hydrophyllum occidentale* Gray. Western water-leaf.—West side of mountain and on northeast slope, common in moist woods and along streams. Humid Transition and Canadian.

2. NEMOPHILA Nutt.

1. *Nemophila parviflora* Dougl. Wood nemophila.—Moist shady locations along City Creek, common on south slope. Humid Transition.

3. PHACELIA Juss.

1. *Phacelia heterophylla* Pursh. Vari-leaved phacelia.—Along dry roadside to the summit; common. Transition.

4. ROMANZOFFIA Cham.

1. *Romanzoffia sitchensis* Bong. Mist maidens.—Fairly common on wet rocky slopes of north side. Canadian and Hudsonian.

41. BORAGINACEAE—Borage Family

Nutlets with prickles on the margins 1. *Hackelia*
Nutlets without prickles 2. *Cryptantha*

1. HACKELIA Opiz.

1. *Hackelia floribunda* (Lehm.) Johnst. Stickseed.—On west slope along road to summit; not common. A new locality for this plant. It has been previously reported from the Wallowa Mountains of Oregon.

2. CRYPTANTHA Lehm.

1. *Cryptantha Hendersonii* (Nels.) Piper. Large-flowered cryptantha.—Near summit of the mountain just below the lookout; not common. (Gilkey, July 11, 1941). Transition.

42. LABIATAE—Mint Family

Flowers in close spike-like clusters; upper pair of stamens longer than the lower 1. *Agastache*
Flowers in axillary, interrupted clusters; upper pair of stamens shorter than the lower 2. *Stachys*

1. AGASTACHE Clayt.

1. *Agastache urticifolia* (Benth.) Ktze. Hyssop.—Locally abundant along Sharps Creek Road on open southwest slope. An interesting appearance of this species in the region. It is common throughout eastern Oregon in dry woods and on open slopes. The plant is also reported from eastern Curry County. Arid Transition.

2. STACHYS L.

1. *Stachys rigida* Nutt. Hedge-nettle.—Only one station. Growing at summit. Canadian.

43. SCROPHULARIACEAE—Figwort Family

Upper lip of the corolla not helmet-shaped

Corolla nearly regular; stamens 2

Corolla rotate; leaves opposite, all cauline 4. *Veronica*

Corolla campanulate; leaves mostly basal; the few cauline leaves alternate 5. *Synthyris*

Corolla irregular, strongly 2-lipped; stamens 4 or 5 (one sterile)

Stamens 5, one sterile

Sterile filament long, about equalling the other stamens 2. *Penstemon*

Sterile filament not developed, but represented by a gland or scale attached to the upper side of the corolla 1. *Collinsia*

Stamens 4, all fertile 3. *Mimulus*

Upper lip of the corolla helmet-shaped

Anther cells unequal; bracts very often showy

Upper lip of the corolla much exceeding the lower; calyx usually 2-cleft 6. *Castilleja*

Upper lip of the corolla but little exceeding the lower; calyx mostly evenly 4-lobed 7. *Orthocarpus*

Anther cells equal; bracts not showy 8. *Pedicularis*

1. COLLINSIA Nutt.

1. *Collinsia parviflora* Dougl. Small innocence.—Dry ground along Utopian Way; common. Transition.

2. PENSTEMON Mitch.

Inflorescence compound; seeds winged; anthers always woolly 5. *P. nemorosus*

- Inflorescence simple or nearly so; seeds wingless; anthers either glabrous or woolly
 Tall herbaceous plants; leaves quite thin1. *P. procerus*
 Low half-shrubby plants, leaves leathery
 Flowers purple
 Leaves mostly lance-oblong to long-elliptic2. *P. Cardwellii*
 Leaves oval to spatulate or roundish3. *P. Davidsonii*
 Flowers crimson4. *P. rupicola*
 1. *Penstemon procerus* Dougl. Tall penstemon.—South side of road below the lookout tower; common. Hudsonian.
 2. *Penstemon Cardwellii* Howell. Cardwell's penstemon.—Frequent along the roadside on west slope. Hudsonian.
 3. *Penstemon Davidsonii* Greene. Davidson's penstemon.—Growing at summit on rocks and cliffs. This species inhabits the high mountains of the Cascade Range. Hudsonian.
 4. *Penstemon rupicola* How. Crimson penstemon.—Found only at summit. Hudsonian.
 5. *Penstemon nemorosus* (Dougl.) Traut. Turtle-head.—Moist woods of northwest slope; common. Canadian and Hudsonian.

3. MIMULUS L.

- Flowers yellow
 Stem weak, leaves slimy-glandular1. *M. moschatius*
 Stem erect, leaves not as above2. *M. guttatus*
 Flowers rose or reddish3. *Br. w. ri*
 1. *Mimulus moschatius* Dougl. Musk.—Common in moist places along Utopian Way. Transition.
 2. *Mimulus guttatus* DC. Common monkey-flower.—Growing beside a spring along Utopian Way; not common. Humid Transition and Canadian.
 3. *Mimulus Breweri* (Greene) Cov. Brewer's monkey-flower.—Open hillside near Musick Mine; not common. Not previously known to occur in this region. This is an extension of the range of this plant from east of the Cascades. Canadian and Hudsonian.

4. VERONICA L.

- Perennials
 Racemes all axillary1. *V. americana*
 Raceme one, terminal2. *V. serpyllifolia*
 Annual3. *V. arvensis*
 1. *Veronica americana* (Raf.) Schwein. Common speedwell.—West slope along Utopian Way near a small spring, very common in moist situations. Transition.
 2. *Veronica serpyllifolia* L. Thyme-leaf speedwell.—Growing in a marsh near Musick Mine; common. Transition.
 3. *Veronica arvensis* L. Corn speedwell.—Common in open woods about springs on Utopian Way, west slope. Introduced from Europe. Transition.

5. SYNTHYRIS Benth.

1. *Synthyris reniformis* (Dougl.) Benth. Spring Queen.—Woods, west slope of mountain; very common early in the growing season. Humid Transition.

6. CASTILLEJA Mutis.

- Leaves entire, glabrous1. *C. miniata*
 Leaves cleft into linear lobes, somewhat hairy2. *C. hispida*
 1. *Castilleja miniata* Dougl. Common paintbrush.—Open southeast slope at high elevations; very common. Transition to Hudsonian.
 2. *Castilleja hispida* Benth. Indian paintbrush.—Growing along Utopian Way; common. Transition.

7. ORTHOCARPUS Nutt.

1. *Orthocarpus imbricatus* Torr. Mountain owls-clover.—Very common at summit and on northwest slope. This is a very striking and beautiful plant of the high mountains. Hudsonian.

8. PEDICULARIS L.

Leaves lanceolate, doubly toothed 3. *P. racemosa*

Leaves pinnately divided; flowers yellowish-white

Upper lip of the corolla forming a slender inrolled beak 2. *P. contorta*

Upper lip of the corolla not forming an inrolled beak 1. *P. flavida*

1. *Pedicularis flavida* Penn. Indian warrior.—North slope just below edge of the melting snow; not common. Canadian and Hudsonian.

2. *Pedicularis contorta* Benth.—Hillside at Lead Crystal Mine, moist marshy ground; rare. (Sidney A. King, May 27, 1934). Hudsonian.

3. *Pedicularis racemosa* Dougl. Mountain figwort.—Fairly common in shaded woods growing in moist humus soil of northwest slope. Hudsonian.

44. OROBANCHACEAE—Broom-rape Family

1. OROBANCHE L.

1. *Orobanche fasciculata* Nutt. Naked broom-rape.—Rare along Utopian Way. Transition to Canadian.

45. PLANTAGINACEAE—Plantain Family

1. PLANTAGO L.

1. *Plantago lanceolata* L. English plantain.—Very common on summit and on northwest slope. A widespread weed. Introduced from Europe.

46. RUBIACEAE—Madder Family

Flowers pink, surrounded by involucre 2. *Sherardia*

Flowers not pink, not involucre 1. *Gaium*

1. GALIUM L.

Leaves 6 to 8 in a whorl

Leaves linear-spatulate; flowers white 1. *G. Aparine*

Leaves elliptic-lanceolate; flowers greenish-white 2. *G. triflorum*

Leaves 4 in a whorl

Annual; leaves often reduced to 2 at the upper nodes, or if 4, 1 pair shorter than other 4. *G. bifolium*

Perennial; leaves always 4 at a node 3. *G. oreanum*

1. *Galium Aparine* L. Annual bed-straw.—Shady woods of northwest slope; very common. Transition.

2. *Galium triflorum* Michx. Fragrant bed-straw.—Open woods near Musick Guard Station; common. Transition.

3. *Galium oreganum* Britt. Northern wild licorice.—On road to summit; common. Canadian.

4. *Galium bifolium* Wats. Twin-leaved bed-straw.—Wet ground of south slope, early; common. Canadian.

2. SHERARDIA L.

1. *Sherardia arvensis* L. Field madder.—Dry ground along Sharps Creek Road below lookout. (Gilkey, July 11, 1941). Introduced from Europe.

47. CAPRIFOLIACEAE—Honeysuckle Family

Leaves simple

Flowers tubular or funnelliform

Shrubs, erect or climbing

Flowers zygomorphic; fruit red or black, berry-like 1. *Lonicera*

Flowers actinomorphic; fruit white, berry-like	2. <i>Symphoricarpos</i>
Vine, prostrate or creeping; flowers in pairs	3. <i>Linnaea</i>
Flowers rotate	4. <i>Viburnum</i>
Leaves compound	5. <i>Sambucus</i>

1. LONICERA L.

Climbing shrubs; flowers orange-red	1. <i>L. ciliosa</i>
Erect shrubs; flowers white	2. <i>L. utahensis</i>

1. *Lonicera ciliosa* (Pursh) Poir. Climbing honeysuckle.—Bohemia saddle; not uncommon. Transition.

2. *Lonicera utahensis* Wats. Utah honeysuckle.—Common locally along Utopian Way, also on Bohemia saddle, with small patches on southwest slope near summit. This is a species of the Blue and Wallowa Mountains and eastward, and has not previously been reported from our area. A good example of discontinuous distribution. Hudsonian.

2. SYMPHORICARPOS L.

Erect shrub; corolla 5-6 mm. long	1. <i>S. rivularis</i>
Creeping or decumbent shrub; corolla 2-4 mm. long	2. <i>S. hesperius</i>

1. *Symphoricarpos rivularis* Suksd. Snowberry.—At lower altitudes on mountains; common. Transition.—*S. albus* of Oregon authors.

2. *Symphoricarpos hesperius* G. N. Jones. Creeping snowberry.—At summit; common. Transition.—*S. mollis* of Peck's Manual.

3. LINNAEA L.

1. *Linnaea borealis* L. var. *americana* (Forbes) Rehder. Twinflower.—In rich humus soil of forest floor along Utopian Way; common. Humid Transition and Canadian.

4. VIBURNUM L.

1. *Viburnum ellipticum* Hook. Western wayfaring tree.—Open woods and thickets on west slope and along Utopian Way; not common. Humid Transition.

5. SAMBUCUS L.

Inflorescence flat-topped; fruit blue	1. <i>S. coerulea</i>
Inflorescence pyramidal; fruit red	2. <i>S. callicarpa</i>

1. *Sambucus coerulea* Raf. Blue elderberry.—Northwest slope along Utopian Way; scattered. Transition.—*S. glauca* Nutt.

2. *Sambucus callicarpa* Greene. Red elderberry.—Edge of receding snowbank, north slope; not common. Humid Transition to Hudsonian.

48. VALERIANACEAE—Valerian Family

1. VALERIANA L.

1. *Valeriana sitchensis* Bong. Mountain valerian.—Northeast slope at 5,800 feet, moist places. Hudsonian.

49. CUCURBITACEAE—Gourd Family

1. ECHINOCYSTIS T. and G.

1. *Echinocystis oregana* Cogn. Wild cucumber.—Open west slope; rare. Transition.

50. CAMPANULACEAE—Bell-flower Family

1. CAMPANULA L.

Flowers dark blue; leaves nearly sessile	1. <i>C. prenanthoides</i>
Flowers pale blue; leaves petioled	2. <i>C. Scouleri</i>

1. *Campanula prenanthoides* Dur. Slender blue-bell.—Rocky soil along Utopian Way on northwest slope; infrequent. Humid Transition.

2. *Campanula Scouleri* Hook. Pale blue-bell.—Sharps Creek Road; common. Humid Transition and Canadian.

51. COMPOSITAE—Sunflower Family

Flowers all ligulate; juice milky

Pappus plumose1. *Hypochaeris*

Pappus not plumose

Heads solitary; leaves all basal2. *Agoseris*

Heads several; cauline leaves present3. *Hieracium*

Flowers all tubular, or heads composed of both tubular and ligulate flowers

Pappus of hairs or bristles

Heads with both ray and disk flowers

Leaves mostly opposite13. *Arnica*

Leaves alternate

Ray flowers yellow

Involute bracts usually narrow, in 1 or 2 even series15. *Senecio*

Involute bracts in several series, usually overlapping14. *Haplopappus*

Ray flowers not yellow

Involute bracts narrow, usually in an even series, sometimes 2; rays narrow, numerous5. *Erigeron*

Involute bracts in several series, broader, generally overlapping; rays fewer4. *Astragalus*

Heads with disk flowers only

Flowers white or whitish

Leaves prickly16. *Cirsium*

Leaves not prickly

Pappus bristles of staminate flowers club-shaped6. *Antennaria*

Pappus bristles not as above7. *Anaphalis*

Flowers bright yellow

Leaves opposite13. *Arnica*

Leaves alternate

Heads few-flowered12. *Luina*

Flowers numerous15. *Senecio*

Pappus none

Flowers white

Ray flowers none8. *Adenocaulon*

Ray flowers present

Heads numerous; rays 4 or 59. *Achillea*

Heads solitary; rays numerous10. *Chrysanthemum*

Flowers yellowish or greenish11. *Artemisia*

1. HYPOCHAEERIS L.

1. *Hypochaeris radicata* L. False dandelion.—Occasional along roadside on north slope. Introduced from Europe.

2. AGOSERIS Raf.

Flowers orange; leaves entire or slightly toothed1. *A. aurantiaca*

Flowers yellow; leaves sharply toothed or deeply cleft2. *A. laciniata*

1. *Agoseris aurantiaca* (Hook.) Greene. Burnt-orange dandelion.—Roadside near Summit. Hudsonian.

2. *Agoseris laciniata* (Nutt.) Greene. Tall false dandelion.—Utopian Way; rare. Humid Transition.

3. HIERACIUM L.

Flowers white1. *H. albidiflorum*

Flowers yellow

Plant 20 cm. or less; basal leaves glabrous4. *H. gracile*

Plant much taller; leaves pubescent

- Involucral bracts narrowly linear2. *H. cynoglossoides*
 Involucral bracts broadly linear3. *H. Parryi*
 1. *Hieracium albiflorum* Hook. White-flowered hawkweed.—Sharps Creek Road; common. Transition.
 2. *Hieracium cynoglossoides* Arv. var. *nudicaule* Gray. Naked-stemmed hawkweed.—Open gravelly north slope; local. Canadian and Hudsonian.
 3. *Hieracium Parryi* Zahn. Parry's hawkweed.—South slope in open; not common. Canadian.
 4. *Hieracium gracile* Hook. Alpine hawkweed.—North slope just below summit; rare. Hudsonian.

4. ASTER L.

- Stems very leafy to top; leaves thin, cottony-pubescent beneath, margins entire or nearly
 so1. *A. ledophyllus*
 Stems not so leafy; leaves leathery, hash-pubescent, margins sharply toothed2. *A. radulinus*
 1. *Aster ledophyllus* Gray. Cascade aster.—North slope, Champion Creek-Sharps Creek Divide; common. Hudsonian.
 2. *Aster radulinus* Gray. Rough-leaved aster.—Fairly common along Utopian Way. Transition.

5. ERIGERON L.

- Heads lilac, pink, or blue
 Leaves relatively large, usually broadly lanceolate1. *E. Aliceae*
 Leaves relatively small, usually numerous and narrow2. *E. foliosus*
 Heads white3. *E. cascadenis*
 1. *Erigeron Aliceae* How. Alice's erigeron.—Common at summit and on northwest slope in gravelly soil. Hudsonian.
 2. *Erigeron foliosus* Nutt. var. *confinis* (How.) Jeps. Leafy daisy.—Summit near old lookout station; fairly common. A new locality for this plant which is common farther south. This is one of the species found commonly along the Rogue River and in the southern counties of Oregon. It grows on dry slopes in both Josephine and Curry counties. Arid Transition.
 3. *Erigeron cascadenis* Heller. Cascade erigeron.—Summit of east slope, growing on rocks and in crevices. This is a very rare plant which has been collected only a few times. Apparently the most northern collection recorded to this date. It has a very local distribution in the Cascades or in the foothills west of the Cascades from Hershberger Mountain north to the Calapooya Mountains. Common also on the summit of neighboring Bohemia Mountain above 5,900 feet. Hudsonian.

6. ANTENNARIA Gaertn.

1. *Antennaria rosea* Greene. Rosy everlasting.—Fairly common on west slope. It appears in our region from the summit of the Cascade Mountains. Hudsonian.

7. ANAPHALIS DC.

1. *Anaphalis margaritacea* (L.) B. & H. var. *subalpina* Gray. Alpine pearly everlasting.—On open hillsides south slope; common. Hudsonian.

8. ADENOCAULON Hook.

1. *Adenocaulon bicolor* Hook. Pathfinder.—North slope, growing in shady woods; common. Humid Transition to Canadian.

9. ACHILLEA L.

1. *Achillea lanulosa* Nutt. Western yarrow.—Rocky soil, north slope; abundant. Sometimes with pink rays. Hudsonian.

10. CHRYSANTHEMUM L.

1. *Chrysanthemum leucanthemum* L. Ox-eye daisy.—Dry ground along edge of the road to summit, south slope; not common. Introduced from Europe.

11. ARTEMISIA L.

1. *Artemisia ludoviciana* Nutt. Common wormwood.—Occasional on south and east slope. A species from eastern Oregon not previously known to occur west of the Cascades. This is a new record for our area. Arid Transition.

12. LUINA Benth.

1. *Luina stricta* (Greene) Robins. Rainiera.—Growing in the rocky soil of northwest slope, and on Elephant Saddle; scattered. An interesting extension of this plant southward as it has not been previously reported south of Mount Hood in Oregon and was originally thought to be an endemic of the state of Washington. Canadian and Hudsonian.—*Rainiera stricta* Greene.

13. ARNICA L.

Stems glabrous or nearly so, not glandular 1. *A. latifolia*
Stems glandular and sticky throughout 2. *A. diversifolia*

1. *Arnica latifolia* Bong. Broad-leaved arnica.—Growing in humus soil of north slope; common. Hudsonian. The shade forms differ considerably from the sun forms.

2. *Arnica diversifolia* Greene. Sticky arnica.—Common in open woods of north slope. This is the species so common on the east slope of the Cascades. The first record for western Oregon. Hudsonian.

14. HAPLOPAPPUS Cass.

1. *Haplopappus Hallii* Gray.—Dry ground growing at the summit of northwest slope of the mountain; common locally. This species has been previously reported as a narrow endemic on the bluffs of the Columbia River in northern Oregon. Our plant needs considerable study. It is probably an undescribed variety. There are a number of characters which do not agree with the above named plant. Hudsonian.

15. SENECIO L.

Stem leaves pinnately divided or compound 1. *S. Harfordii*
Stem leaves not as above, often toothed

Stems leafy throughout 2. *S. triangularis*

Stems few-leaved or naked above 3. *S. integerrimus*

1. *Senecio Harfordii* Greene. Harford's senecio.—Fairly common on west slope. A southern extension of the range of this plant. It is more common around Mt. Hood but is reported by Peck (1941: 778) to reach the McKenzie Pass. Canadian.

2. *Senecio triangularis* Hook. Spear-head senecio.—Very common on moist north slope. Hudsonian.

3. *Senecio integerrimus* Nutt. var. *exaltatus* (Nutt.) Cronq. Tall western senecio.—Growing on south side of the road on saddle nearly to the summit; scattered stations. Hudsonian.

16. CIRSIIUM Scop.

1. *Cirsium centaureae* (Rydb.) K. Schum. Slender mountain thistle.—Open summit of mountain; rather rare. Hudsonian.—*C. americanum* (Gray) Robs. of Peck's Manual.

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Mobility of the Sharp-tailed Grouse in Relation to Its Ecology and Distribution

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This paper is one of a series based in part on work done in the course of the Wisconsin Prairie Chicken Investigation, a study of both the Greater Prairie Chicken (*Tympanuchus cupido pinnatus*) and the Prairie Sharp-tailed Grouse (*Pedioecetes phasianellus campestris*). For the early history of that Investigation, see Leopold (1936).

¹ A joint contribution from the Edwin S. George Reserve, University of Michigan, and the Department of Wildlife Management, University of Wisconsin.

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INTRODUCTION

Sharp-tailed grouse move in patterns that vary with the seasons, with the weather. These patterns vary also according to sex, and undoubtedly according to individual behavior.

We have studied sharp-tails in the central and northern parts of Wisconsin and Michigan. Our major study area was the Central Wisconsin Game Project, Necedah, a 100,000-acre tract then under development by the U. S. Resettlement Administration. It lies in northern Juneau, southern Wood, southeastern Jackson, and eastern Monroe counties. It consists of interspersed sand ridges and islands, marshes and swamps. Once it was part of the bed of Glacial Lake Wisconsin. It was lumbered off in the late 1800's and drained for agriculture in the early 1900's. At the time of our work there (August 1935 through September 1937) the original plant cover had long since been destroyed. Plant succession had been turned back to a much earlier stage of development over most of the area.

Drainage and fire, axe and plow, had wrought this change. Close to the ditches—where drainage was most effective—there were bluegrass meadows (*Poa pratensis*). Where drainage had been less successful, and there was standing water through part of the year, there were bluejoint-sedge marshes (*Calamagrostis-Carex*) or willow swales (*Salix*). The "Great Swamp" of central Wisconsin, hundreds of thousands of acres of tamarack and black spruce (*Larix laricina* and *Picea mariana*) with some bluejoint-sedge marsh, once covered a great part of the area. Only a few shreds and tatters of the old swamp were left. Fires have swept the drained peat again and again. Fire sometimes changed timbered swamp to open marsh, sometimes brought in solid stands of aspen (*Populus tremuloides*) and willow, now in small patches and again in blocks of several thousand acres. In places the peat was burned out to the underlying sand. The lowland had thus become a hodge-podge of thickets and openings of divers sizes and shapes, with only an occasional remnant of swamp to show what the peatlands once were like.

The sandy uplands had also become a patchwork of openings, thickets, and woods. Jack pine and scrub oaks (*Pinus Banksiana* and *Quercus*) alternated with open grassy areas and heaths of blueberry, huckleberry, and sweet

fern (*Vaccinium*, *Gaylussacia*, *Myrica asplenifolia*). The region once grew fine stands of red and white pines (*Pinus resinosa*, *P. Strobus*). Lumbering, fire, clearing for agriculture, and a lowered water table had completely changed its former aspect.

Parts of the area—both upland and lowland—were under cultivation. A few of the meadows and marshes were cut for hay. The sandy fields were not highly productive. The drained peat was sour and cold; drainage taxes were high. Much of the land had become tax delinquent. The Federal government was in process of buying the land and moving the few remaining farmers to other lands.

In short, the original timber on both sand and peat was virtually gone. In its place, for a time, was a mixture of large openings and brush² patches. This made excellent prairie grouse country, for a time the best in the Middle West. The uplands, however, have been reverting slowly to forest, partly through natural succession and partly through artificial plantings. Brush, the vanguard of the forest, is likewise taking over the meadows and the marshes, where fire has hastened the invasion a thousand-fold. The last big fire was in 1930. By 1936, when we were there, the prairie chickens were almost gone and the end for the sharp-tails was in sight, so quickly had the brush taken over. Now, in 1948, the huge aspen flats are too dense and too tall for the prairie grouse. They are too monotonous to make good ruffed grouse habitat, for they lack enough interspersions with other types. They are of little use for pulp or lumber, for they are stunted by poor soil and heart rot. They are, to us, a poor substitute for the proud swamp that once grew there, or for the crane, "chicken," and duck marshes which they have so recently supplanted.

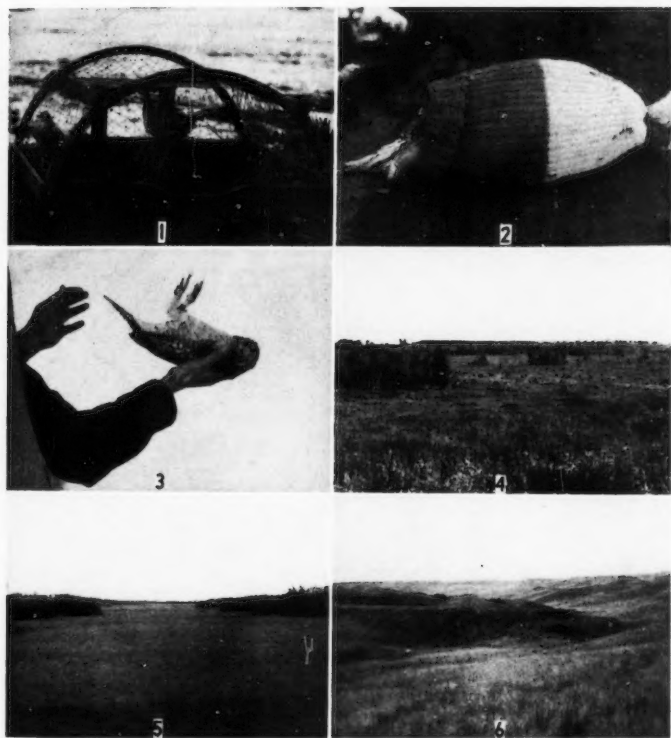
This, of course, is no more than a quick skimming-over of a complex and deeply interesting sequence of events (for more detail see Leopold 1934, 1937; Hamerstrom 1938, 1939; Thomson 1943; Scott 1947b; Grange 1948). *Throughout the Lake States this same sequence is running its course, with minor variations, on most of the present range of the prairie grouse.* Lumbering, fire, and clearing made new range in what was originally timberland. By now much of this new range is too intensely farmed to be suitable for prairie grouse. Much of it has already reverted to brush and timber. A little still remains, and that little becomes less and less each year as grass gives way to trees.

There are a few areas in which this sequence has begun so recently that it still has some years to run. Some new habitats may develop as a result of fire, but fire control has become so much more effective that large burns occur more and more rarely. There are a few areas in which the natural return of the forest is slower than usual because the soil has been "run out." Many of these areas are being artificially replanted to trees to hasten the process of reversion to forest, and more and more planting is in prospect. There are a

² We use "brush" to mean not only shrubs but also the young growth of trees. Thus aspen is, strictly speaking, a forest tree—but aspen reproduction is a kind of brush according to our usage.

few areas which will persist as openings longer than others because frost cuts back the encroaching seedlings. In time they too will likely close in.

That Wisconsin sharp-tails still have any habitat left is thus a matter of pure chance. Their luck is running out. The conclusion is inescapable: if Wisconsin wants to keep sharp-tails on the game bird list, sharp-tail management is essential.



Figs. 1-3.—Sharp-tail trapping on the Necedah area, 1936-37. 1. Half-wheel trap on a bed of buckwheat straw; 2. Ready for weighing and banding; 3. Releasing a banded bird.

Figs. 4-6.—Sharp-tail habitat. 4. "The Big Burn," Drummond Island, Michigan, October 1946. This is one of the finest sharp-tail areas remaining in the Lake States; 5. Sharp-tail habitat near Inwood, Manitoba, September 1939; 6. Brush patches in the draws and coulees which finger into the grasslands are important elements of sharp-tail range in the Dakotas: northwest of Mobridge, South Dakota, October 1948.

A beginning has already been made, although it has not yet passed beyond the experimental stage. Our work, like most of the Wisconsin Prairie Chicken Investigation before our time, was concerned mainly with studies on life history and ecology. This report on sharp-tail movements is based on unpublished bandings by Franklin J. W. Schmidt and the U. S. Forest Service in Wisconsin (Table I), supplemented by our own field observations in both Wisconsin and Michigan. To the Wisconsin-Michigan material we have added a survey of sharp-tail movements in other regions.

TABLE I.—Sources, dates, and quantities of sharp-tail banding data.

Source	Dates		Number banded	Number retaken
	from	through		
Schmidt	1930-31	1932-33	657	119
U. S. Forest Service	1936-37	1940-41	108	55
Soil Conservation Service	1936-37	1939-40	3
			765	177

Number retaken: Birds retrapped, shot, or found dead. Some were re-trapped and later shot or found dead; such birds are here counted only once.

ACKNOWLEDGMENTS. *Schmidt*: Franklin J. W. Schmidt, who was assisted by several trappers whose names we do not know. The birds retaken were banded in Wood (114) and northern Juneau (5) counties; 5 are returns on Wood county birds which were released in Adams County. *U. S. Forest Service*: The following men were in charge of banding—on the Nicolet National Forest (42 birds retaken), Mr. Deane W. Mather; on the Chequamegon National Forest (13), Messrs. W. W. Barton and C. M. Evenson. *Soil Conservation Service*: The Necedah area was first a project of the U. S. Resettlement Administration and later part of the Soil Conservation Service. Banding in 1936-37 was under our direction (see Hamerstrom and Truax, 1938, for methods), during the last three years under that of Mr. William H. Schunke. Only three returns are used in this paper. The rest—the great majority—are treated in a report (unpubl.) by the Soil Conservation Service.

LOCAL MOVEMENTS IN WISCONSIN AND MICHIGAN

AUTUMN

Cover preferences in late summer and early fall.—In the Necedah-Babcock region sharp-tails spent the late summer and early autumn in small groups, generally of 12-15 birds or less. At that season we most often found them or—more commonly—their roosts, dusting places, and stray feathers in open herbaceous cover, in scattered low brush, or in the sandy open heaths: i.e., in or close to breeding cover. There were both prairie chickens and sharp-tails in the area, and we often could not read sign accurately enough to tell the roosts and dust baths of one from the other; nevertheless, we found little evidence that *either* species was using the thicker brush and woodlands to any

great extent at this time of year. As the autumn advanced two changes occurred. Both sharp-tails and prairie chickens began to go to the aspen thickets and the open oak woods and to spend more and more of the day there. Night roosts, however, were still in the open. And at this same sea-



Figs. 7-9.—Sharp-tail habitat. 7. Sharp-tail habitat in the "Cut-over": Kingston Plains, northern Michigan, October 1946. Poor soil, repeated fires, and frost have held back brush invasion here; 8. Drained and burned peat: south of Walsh, Michigan, October 1946. We saw autumn dancing here. Aspen invasion in the background; 9. Winter range in central Wisconsin: northeast of Bear Bluff, March 1937. Open oak-pine woods on the uplands, aspen and open marsh on the lowlands. The uniform gray areas are "popple flats"—huge areas of aspen on drained and burned peat.

Figs. 10-12.—Autumn cover. 10. Sharp-tails prefer thickets with open ground cover: Maxton Plains, Drummond Island, Michigan, October 1947; 11. Ground cover in a much-frequented aspen thicket on "The Big Burn," Drummond Island; October 1947; 12. Thickets with a dense grassy undercover are seldom used in autumn: Maxton Plains, Drummond Island, October 1947.

son the sharp-tail cocks began to go again to their dancing grounds. As chilly mornings came more often, the cocks went more and more regularly to the dancing grounds to display.

The shift to brush.—We have seen these same two changes in Michigan also, in places where there were few or no prairie chickens to confuse the picture—in Kalkaska and Schoolcraft counties, and on Drummond Island. On Drummond Island, for example, in October 1946 we found a great deal of old sign (from summer and early autumn) in the open grassy areas of the "Big Burn." Except for night roosts and dancing grounds, most of the fresh sign was in patches of aspen and willow scattered through the grassland. And except in the early morning and toward dusk, we could count on finding the coveys in the brush patches or in their edges. In the mornings, about sunrise, we often heard dancing sharp-tails. Several times we flushed them from a dancing ground near our camp. In October 1947 we camped and hunted in the same area. Again we found a great deal of old sign in the grassy cover, but this time there was much fresh sign too. At first there was rather little sign in the brush patches, and none at all in certain ones which the sharp-tails had used daily the autumn before. Toward the end of the first week in October the birds were going to the thickets more regularly, and had again appeared in the ones which, although used the year before, had showed no sign when we first went to them in 1947. Even after ten days, however, the sharp-tails were still spending more time in open cover than they had during the same period in 1946. They did not wholly settle down to spending their days in the thickets until sometime between the fifteenth and twentieth. The dancing grounds likewise showed much less sign of use than they had the year before, especially in early October.

Altogether, we have hunted sharp-tails during five autumns: in Wisconsin in 1938 and 1939, and in Michigan in 1943, 1946, and 1947 (and for a few days in North Dakota in 1948). We watched them without hunting during the autumns of 1935 and 1936 on the Necedah area. We have not traced marked birds from open cover in summer and early autumn into brush and open woods later in the fall; nevertheless, on the basis of the kind of evidence given above, we are convinced that such a change in habits does occur. It occurs at about the time of the beginning of leaf-fall in the aspens, but some weeks before the thickets are bare and well before the grass and leaves have seared. It is sometimes supposed that this change in habits is the result of shooting. Although hunting pressure may keep sharp-tails in denser brush than they otherwise use regularly, the birds have generally begun to resort to the thickets before the hunting season opens in October. As a matter of fact, sharp-tails take to the brush in the autumn when they are not hunted at all.

Autumn display.—In general, the autumn dancing grounds are the same ones that are used in spring. We suspect that dancing grounds are sometimes established in the fall. As in spring, sharp-tails sometimes dance as they come off their night roosts wherever they happen to be, but the dancing grounds are the main theatres for the performance. We cannot say exactly

when autumn dancing first begins, but the dancing grounds begin to show fresh droppings, feathers, and trampled vegetation by the time that sharp-tail sign is appearing in the brush patches. Sign on the dancing grounds does not become conspicuous, however, until somewhat later. Sharp-tails are most apt to dance when the early morning is brisk and still—when there is a snap and sparkle in the air and the smoke of a cook fire, kindled before sunrise, stands straight and steady as a rampike. The dance is much less lively, or passed up altogether, when the morning is warm and lazy or raw and windy.

Because autumn dancing concentrates cocks in the early mornings it brings about some segregation of the sexes. We have seen only dancers—i.e., only cocks—on the display grounds in about 12 mornings of autumn watching.³ We followed one group of dancing ground males on the Necedah area practically all day long during five days in the autumn of 1938. The birds did not move farther than a mile from the dancing ground, and it happened that there were no other coveys within that radius. On the other hand, we have followed other dancing ground males into thickets which were also being used by other coveys; in these thickets we have shot adults and young of both sexes. But except as they casually meet other coveys in certain coverts or grainfields which are used in common, dancing ground cocks seem to keep to themselves in early autumn. Later they probably join the others, at the time of pack formation. Aside from their visits to the dancing grounds, they appear to spend the day like any other autumn covey.

Daily movements and covey range.—Both the shift to brush and the recrudescence of display require some change in daily movements. In most of the sharp-tail range in Wisconsin and Michigan these movements need not be long. In these two states, as in the Lake States generally, sharp-tails were long ago driven from the prairies. Their present habitat consists of relatively small openings in brushland or forest. The dancing grounds are usually in the openings themselves, and thickets or open woods can generally be found within a few hundred yards—at most within a mile or so. When sharp-tails nested on the prairie, they often had to go much farther to get to autumn and winter cover (see "Migration," below).

After sharp-tails have first begun to go to woody cover, we have most often found them in coveys of 8-10 to about 30 birds. When flushed, a covey often flies a half mile to a mile or more at a stretch. It is apt to get out of sight, and to swerve aside from the direct line of flight, before coming to ground again. After finding a few coveys and losing them in this way, one

³ On the afternoon of 25 September 1948, with Roy N. Bach we watched about 18 dancing cocks in Slope County, North Dakota. At least three of the dancers had the third primary from the outside (on each wing) about a fourth shorter than the neighboring remiges. In other words, they were young of the year (Bent, 1932; Wright and Hiatt, 1943; Ammann, 1944; Petrides, 1945). We have long suspected that young cocks took part in autumn dancing, but this is the first positive evidence of it that we have found. It is probably much more common than this single observation would suggest.

gets the impression that sharp-tails move widely and at random at this season. They seem to have no covey range as the bob-white does, for example. This is really not the case. They do have a covey range: it is large, but none the less real. In it certain thickets, open woods, and edges are used day after day, while others are seldom or never visited. Repeatedly, in different areas and in different years, we have learned the habits of a number of coveys. After working out the pattern for a given covey, we could generally find the birds in one or another of their familiar places. We seldom found them in coverts which did not show sign that sharp-tails had been there before. Although the favored thickets and edges were often scattered through an area of 1,000 to 1,500 acres, they ordinarily were not more than three to six in number and totalled about 100-200 acres in extent. These acreage figures are only estimates, and should be refined by cover mapping and planimetry. Nevertheless, they are useful in pointing out that although sharp-tail coveys range over a fairly large piece of ground, they actually spend their time during the day in a few spots to which they return again and again. Night roosts and dancing grounds are generally in the openings (sometimes in scattered brush) in which or around which the patches of woody cover are dispersed.

We have seen almost identical behavior in prairie chicken packs in central Wisconsin (Hamerstrom and Hamerstrom, 1949). We have been able to study the individual ranges of autumn prairie chicken packs in greater detail because by the time packing had occurred, each range was fairly well separated from the next and each range held only one pack. We have been less successful in finding the exact boundaries of sharp-tail covey ranges as there has often been some overlapping, and the same brush patches have sometimes been used by more than one covey. For all of that we are convinced that in early autumn most sharp-tail coveys do have a definitely circumscribed covey range beyond which they rarely venture. We believe that daily cruising radius is ordinarily about a mile, and may often be as little as a half mile.

Autumn food habits.—Some sharp-tails feed on cultivated grains in the early autumn. Some do not. In the Necedah-Babcock region, for example, we found coveys feeding in fields of buckwheat, corn, and rye. This habit is well known and wide-spread. Nevertheless, there are many areas in northern Wisconsin and northern Michigan in which there are excellent stands of sharp-tails and no grains. Grange (1939: 26) has put it very well: "... they survive successfully many miles from the nearest grainfields, summer and winter, year in and year out. . . . Where good buds and good grain foods are both available, the grouse habitually take some of each type." Those coveys which do eat grains are most apt to visit the stubbles in the early morning, before going to the brush patches, and again in late afternoon before going to roost. As far as we know, they do not make long movements to find grain at this season. Those which do not eat grain get most of their food, and the grain-eaters get some of it, in the brush patches and oak woods and along their edges, where they find such things as acorns, the leaves of strawberry, dewberry, clover, and sorrel; the fruits of bearberry, cherry, and buffalo berry;

TABLE II.—Autumn returns: Hunter kills and birds found dead.

Time of Recovery	Miles from banding place														Total
	0-1	1-2	2-3	4-5	5-6	6-7	7-8	8-9	9-10	11-12	13-14	15-16	20-21	?	
♂ ♂ and ♀ ♀															
1st autumn	33	23	9	3	2	1		1	1	3		2	1	4	83
2nd autumn	7	1		1	1		1			1	1			1	14
3rd autumn	1														1
?					1										1
TOTALS	41	24	9	4	4	1	1	1	1	4	1	2	1	5	99
♀ ♀ only															
Forest Service ...	1	1	1							1				1	5
Schmidt	8	5	2	1			1		1	2				1	21

One bird was banded in October (and shot three days later); one was banded in April. All the rest were banded in winter.
Sources of data: Schmidt, 91 (67 ♂ ♂, 21 ♀ ♀, 3 ?), U. S. Forest Service, 8 (1 ♂, 5 ♀ ♀, 2 ?).

and sometimes grasshoppers in abundance. They also eat some buds and catkins even at this season, including birch, cherry, and aspen.⁴ Dust baths and sunning and loafing places are also in the woods and brush, or along their edges.

Late-autumn packing.—Later in the autumn there is a pronounced change in flocking behavior. In part it is simply a drawing together of coveys with overlapping ranges, probably as the result of their common use of certain coverts. Two or three, and perhaps even more, coveys join to form a pack. At first the packs often break apart into smaller groups but by November they tend to hold together more tightly. As with prairie chickens, cold weather seems to encourage packing and unseasonable warmth tends to cause the packs to break apart again temporarily. Where the birds are congregating in large numbers to feed in a grainfield it is hard to distinguish between packing and fortuitous group feeding. Because of this, we have seen sharp-tail packing to best advantage where the birds were not feeding on grains: on parts of the Necedah area, and in Michigan in Kalkaska and Schoolcraft counties and on Drummond Island. Such packs have been as large as 45 to 65 birds.

Sharp-tails feeding on grains may form even larger packs. In October and November, 1936, many sharp-tails were coming to two buckwheat fields near Bear Bluff in the northwest part of the Necedah area. We once saw about 200 birds fly out of one of these fields together. Still larger packs were reported to us there—up to 500 and more, although we question the accuracy of these figures. There was some admixture of prairie chickens, but the packs were mostly of sharp-tails. Sometimes the birds left the field in a single enormous group, which held together as long as it was in sight. More often the main body broke up into two or three smaller groups, each going a different way. Schmidt (1936) has already reported that Wisconsin sharp-tails form large autumn packs, ranging in size from 20 to several hundred birds. The largest, in Rusk County, was one of more than 400 birds. Barton *et al.* (1938: 6) speak of "flocks or packs of some 300 birds" at food patches on the Moqua Barrens. These packs broke up into groups of 50 birds or less on leaving the food patches.

Autumn band returns.—Autumn band returns are given in Table II. These returns show that some sharp-tails move considerable distances. However, since most of the birds were banded in winter, there is no knowing when the movements actually occurred. Autumn or spring would seem to be the most likely times. Only one of these birds was banded in the fall: it was shot three days later at a distance of two to three miles. Although one bird moved as far as 21 miles, most were shot close to the banding places. Seventy-nine

⁴ For more information on autumn and winter food habits see Aldous (1943), Aughey (1878: 47), Blakiston (1863), Coues (1877 and 1878), Fisher *et al.* (1935), Grange (1939), Gross (1930), Judd (1905), Leopold (1931), McAttee (1936 and 1941), Schmidt (1936), Seton (Thompson, 1891), G. Swanson (1940), Swenk and Selko (1938), and Van Dersal (1938).

per cent of the 94 complete returns were within three miles, and 69 per cent were within two miles. Comparable returns for Wisconsin prairie chickens are many fewer, totalling only 29. About 62 per cent of these returns were within three miles. The sample is a small one, but it suggests that sharp-tails are more sedentary than prairie chickens. Field observation points to the same conclusion.

WINTER

Cover preferences and daily movements.—In the main, sharp-tails in winter appear to live pretty much as they do in late autumn. Practically all of our experience with them in winter has been on the Necedah area. There we found them spending most of their time in the brush and open woods, both in the branches and on the ground beneath. They were in the edges, rather than the deep interiors, of the oak woods, the swamps, and the aspen flats, or around the edges of openings in the woods or brush. They spent some time in the open—for example, while feeding in grain fields—but we never found them more than a few hundred yards from heavy cover even then. We had trouble distinguishing between night roosts of prairie chickens and sharp-tails, but where we could tell the two apart we found prairie chickens roosting mostly in the open and in scattered brush and sharp-tails in scattered to dense brush. Both species sometimes tunneled under the snow and spent the night beneath its surface. Sharp-tails are said to spend the night in trees in winter upon occasion. We did not see this, but we have seen them fly to the tree-tops in the early morning, sometimes before sun-up. In stormy weather sharp-tails sometimes did not leave their roosts all day. Altogether, they were distinctly more a brush and woodland bird than they had been in the warmer months. Except for the special winter movements which we will describe below, the birds did not seem to move widely. We estimate their usual daily cruising radius at about one mile.

Winter food habits.—The great variety of the autumn dietary is, of course, much reduced in winter. Such low-growing foods as bearberries and the leaves of clover and strawberry are much harder to find under the snow, and the fruits of many shrubs have fallen. Where roses grow, their bright red hips stay on the bushes all winter long and are often an important source of food. Winter food consists mainly of buds and catkins,⁴ with whatever else can be found in the way of green leaves, fruits, acorns, and the like.

With the coming of snow there is often a change in the grain-feeding habit. The large packs near Bear Bluff, for example, began to dwindle in December 1936. In January and February, packs of only 30-60 were coming to the very fields to which hundreds had come in November. The same thing happened that winter at a Forest Service food patch on the Moqua Barrens in northwestern Wisconsin; in fact, from 1936 through 1938 all of the food patches on the Barrens had many fewer birds, or none at all, while the ground was covered with snow (Barton *et al.*, 1938). On the Nicolet National Forest, in northeastern Wisconsin, sharp-tails completely disappeared from the Black-

well Camp area after 28 December 1939. A large flock disappeared from the Camp Mountain area during the second week in December, but a smaller number reappeared at a food patch in January and stayed for the rest of the winter. In both areas on the Forest the number of sharp-tails which had been coming to food patches decreased suddenly at the beginning of the winter of 1940-41 (Deane W. Mather, letter). During the autumn of 1939 there were many sharp-tails on the Douglas County Bird Sanctuary, near Gordon, Wisconsin. Most of them disappeared at the time of the first snow, and there were fewer than a dozen birds at 60 feeders through the winter (L. E. Baum, letter). Schmidt (1936: 194) described the early winter shift away from grains in some detail, and concluded that "sharptails use food patches in fall until the first snow of winter, and again in the spring, but not during the winter budding season." We will say more about this in a later section.

*Winter band retakes.*⁵—We know practically nothing of the movements of those sharp-tails—probably the majority—which hold aloof from grains in

⁵ Our usage of "repeat" and "return" follows Lincoln's (1947) definitions. We use "retake" and "recapture" as general terms (Lincoln does not define any) which specify neither the time, place, nor manner of getting later information on banded birds.

TABLE III.—Number of birds recaptured at winter feeding places.

Where recaptured	In place only winters:				In place 2nd winter Elsewhere 3rd winter	Elsewhere only winters:		Totals
	* 1st	2nd	1st & 2nd	1st & 3rd		1st & 2nd	2nd	
In place								
Forest Service ...	48	2	2					52
Schmidt	6	10	4	1				21
Total	54	12	6	1				
Moved								
0-1 mi.					1	1	2	4
1-2 mi.					1			1
2-3 mi.							1	1
Total					2	1	3	
TOTALS		73			2	4		79

* First winter: the winter in which the bird was banded.

Sources of data: U. S. Forest Service, 52 (8 ♂♂, 30 ♀♀, 14 ?). Schmidt, 27 (24 ♂♂, 3 ♀♀).

winter. Retrapping data tell something of the winter movements of those which do eat grain (Table III). The Forest Service banding stations were too widely spaced to give a fair test of winter movements, but Schmidt caught birds at at least 26 stations in five townships⁶ and so was in a better position to detect them. The two sets of data are segregated in Table III.

Of the 27 sharp-tails which Schmidt retrapped, 21 were still at the banding place and were caught nowhere else, two were retaken in place during the second winter and at one other place nearby in the third winter, and four were retrapped only after they had moved to new feeding places. Of the six birds which had moved, none had gone more than three miles. The numerical proportions within so few recaptures are probably not significant, but the data indicate that many of the same birds feed at the same places from day to day, and that some exchange among neighboring feeding places also occurs.

Both sets of data—Schmidt and Forest Service—may fairly be examined in an analysis of the continued use of feeding places. The time intervals between banding and last recapture in place during the first winter were from 4 to 58 days (Schmidt) and from one to 31 days (Forest Service). Schmidt recaptured 16 birds in place during the second winter, including 14 that were never retaken anywhere else and two that were caught at a new place during the third winter. One was retrapped in place during the third winter although it was not caught during the second. Even the birds that did not repeat at the banding place may have had some ties to a definite feeding place, for one was caught twice at a new station during the second winter. Of the 52 Forest Service recoveries, all were in place and most (48) were during the first winter. Four returned the second winter, including two which had repeated during the first. One of these repeated five times during the first winter and three in the second.

Altogether, sharp-tail band retakes at winter feeding places are rather similar to those of Wisconsin prairie chickens, but sharp-tails moved somewhat shorter distances. Some individuals of both species went to their familiar winter feeding places during the same and later winters.

Feeding places in relation to dancing grounds.—Winter feeding places are often close to spring dancing grounds. Baumgartner (1939) found that in Michigan packs of resident sharp-tails tended to stay close to dancing grounds in winter. Other packs, which he thought were winter migrants, ranged more widely, covering as much as five miles in a day. One of Schmidt's trapping stations was a quarter to a half mile from a dancing ground; at this station he banded 65 sharp-tails in three winters. On the Necedah area, sharp-tails fed all through the winter of 1936-37 at two food patches which were only a quarter mile, and at one which was a mile and a quarter, from dancing grounds. We knew of many more instances in which sharp-tails fed near dancing grounds for *part* of the winter, but we cannot be sure that they stayed all winter long. We think that most of them did. We found sharp-tails, or their tracks and feathers, on several dancing grounds in winter, as early as

⁶ A township is 36 square miles, six miles on a side.

4 February 1938 (Hamerstrom 1939). Marshall and Jensen (1937) found that the Columbian sharp-tail (*P. p. columbianus*) often ranges year-long within a mile of the dancing grounds.

There is no proof, however, that any of the sharp-tails in the examples above actually went to these closest dancing grounds in spring, rather than to others farther away. In the spring of 1939 we returned to the Necedah area and caught three banded sharp-tail cocks on three dancing grounds. All three birds had been banded two winters earlier at food patches which were three quarters, one and a quarter, and one and a half miles away. Schmidt retrapped a winter-banded cock on 29 April 1931. We do not know that this bird was retrapped on a dancing ground, but the date of the recapture is strong presumptive evidence that it was. It was only a half mile from the late winter banding place. Interestingly enough, the same bird was shot the next autumn within a mile of the banding place. There is thus some reason to believe that sharp-tail males, like prairie chickens, probably winter close to their familiar dancing grounds.

Sex packing.—The neighborhood of the dancing grounds may have a stronger attraction for cocks than for hens in winter. If so—and it seems likely—sex segregation may result. Leopold (1933: 120) has reported that winter sex segregation does occur in just this way. Schmidt caught 57 cocks, six hens, and two of undetermined sex in three winters at the one of his trapping stations that we know was close to a dancing ground. He caught only two hens each winter at this station, and a maximum of 35 cocks in one winter. At another station he caught 38 cocks and no hens in three winters, at another nine cocks and no hens in one winter. There were six other places at which he caught cocks but no hens, but the catches were so small (1-5 birds) that they do not necessarily indicate sex packs. Except for the first one, we do not know that these trapping stations were close to dancing grounds, and we do not know how big any of the packs were. At six stations he caught more hens than cocks, ranging in numbers from 1:2 to 33:60; the largest catch of hens with no cocks was 0:4. He caught both sexes in equal numbers at three stations (1:1 to 7:7). During the winter that we trapped on the Necedah area we caught only 43 sharp-tails at five stations. At one we caught 21 cocks and no hens, which was within a bird or two of the whole flock, but we could not find a dancing ground nearby in spring. These observations do not conclusively show that there is a relationship between winter sex packing and the dancing grounds, but we suspect that such a relationship does exist.

Return to grains in late winter.—In the Lake States, sharp-tails again congregate at the grain fields at winter's end. This is most apt to happen in late February and early March but unusually late or early springs would undoubtedly alter the time of its occurrence somewhat. The packs have dispersed again by the time the ground is completely bare, or within a short time thereafter. A few birds may come to a given field for another month or so: these are probably birds whose spring range is in the immediate neighborhood.

Winter display.—Although sharp-tail cocks may display at times during midwinter (Grange, 1936; Hamerstrom, 1939), they display more and more often as spring comes nearer. On the Necedah area they often displayed on the grain stubbles during the period of late winter concentration, both before and after the disappearance of snow. Most often the grain stubbles were only "casual" dancing places—i.e., places at which sharp-tails danced occasionally but not regularly (Hamerstrom, 1939). Two buckwheat fields, however, were true dancing grounds, used regularly through the spring of 1937.

SPRING AND SUMMER

Although we know that sharp-tails often winter close to the dancing grounds, spring dispersal plainly requires further study. We also know rather little about daily movements in spring and summer. It seems probable that sharp-tail cocks center their daily activities on the dancing grounds in spring, as prairie chickens do. Like prairie chickens, sharp-tail cocks go to the display grounds twice daily during spring; in fact, the same ground is sometimes used by both species. We knew of three joint booming-dancing grounds on the Necedah area in 1937, and at least one of these was jointly used in 1939. Schmidt (unpubl.) found that most sharp-tail nests were within a mile of dancing grounds. The dancing grounds, therefore, may also serve as a focus of activity for the hens.

SUMMARY OF BAND RETAKES

Wisconsin sharp-tails.—Table IV summarizes all band retakes, whenever and however obtained, of those sharp-tails that were released in place. In all, 167 birds were retaken 242 times. There are five birds (hunter kills) for which we do not know the place of the return. Of the remaining 162, 38 per cent were retaken only at the banding place and 81 per cent were retaken within two miles. The latter figure includes recaptures in place plus the longest moves only of those that were retaken at more than one place. Only 12 per cent had moved more than three miles, and only 10 per cent more than five miles. The longest move was 21 miles. Aldous (1943), who banded 100 sharp-tails in North Dakota, also found that short-range movements were the rule. His farthest return was at 58 miles and the next farthest (among birds released in place) was at seven miles. One each was recovered at two, four, and six miles, and 24 between a quarter mile and one mile. A transplanted bird, the only one retaken, had moved 31 miles.

Thirteen of the birds in Table IV were retaken in place and at one other

Explanation of Table IV: *Retake*—recapture by trapping, hunter kill, or bird found dead. *In place*—where banded. *Away*—not recovered in place. *Same season*—a retake later in the season in which the bird was banded. *Year*—from the date of banding until (but not including) that season of the next year. A bird banded late one winter and retaken early in the next winter is considered a second year return, even though the actual time span in such a case is less than 12 months.

Where more than one time of retaking is listed, each bird was caught at each time. For example, a bird caught in winter and retrapped later that winter, again during the next winter, and again the winter after, is listed as "Same season and 2d & 3d years."

TABLE IV.—Summary of sharp-tail band retakes.

Where and when retaken	Number of banded birds retaken																	no. times retaken	Time of last retake				
	in place	Miles from banding place																	same season	later same year	2d year	3d year	
		0-1	1-2	2-3	4-5	5-6	6-7	7-8	8-9	9-10	11-12	13-14	15-16	20-21	?								
IN PLACE ONLY	43																43	78					
Same season only																							
Same season and:																							
1st year	1																	2	1		5		
2d year	5																	16					
3d year	1																	2				1	
In one year only ..	11																	12			11		
IN PLACE AND AT																							
1 OTHER PLACE																							
Same season and:																							
1st year	8	3	2	2														19					
2d year	3	2																10			3		
2d & 3d years ..	1	1																3				1	
In one year only ..	1																	2			1		
IN PLACE AND AT																							
2 OTHER PLACES																							
2d & 3d yrs. {max.	1	1																3				1	
{min.	1																						
AWAY, RECOVERED																							
AT 1 PLACE																							
1st year	29	23	7	3	1	1		1	1	1	3		2	1	4			76			14		
2d year	8		1	1	1			1			1	1						16				1	
unknown					1													1					
AWAY, RECOVERED																							
AT 2 PLACES																							
{max.																							
1st year	1																						
{min.	1																						
TOTALS	75	46	27	10	4	4	1	1	1	1	4	1	2	1	5		167	242	43	86	34	3	1

place as well (one of these was shot at a place which was not reported). One of them had moved from five to six miles and two had moved between two and three miles. Nine, however, were within two miles of the banding station when last retaken. One of these was caught in place twice during the second winter, and again at a new station between one and two miles away in the third winter. One bird was retaken at three places. It was retrapped in place during the second winter, caught again about a mile away during the third winter, and was shot the following autumn less than a mile from the banding place. One male was banded on March 2 at a winter trapping station, retrapped a half mile away on April 29, presumably at a dancing ground, and was shot the next autumn about a mile from the banding place. These birds, which were retaken at several points and during more than one season or more than one year, give a special emphasis to the trend toward short movements shown by Table IV as a whole.

Comparison with Wisconsin prairie chickens.—Table IV gives a qualitative, rather than a quantitative, analysis of sharp-tail movements. From a comparison of Tables II and III it is plain that hunter-kill retakes show a greater range of movements than retrapping. This is to be expected, since practically all of the sharp-tail range is hunted and only a small part of it can feasibly be trapped. Neither hunter-kills nor retraps alone are enough to tell the whole story, since neither one gives information for all seasons of the year. A combination of the two (especially since some birds were both retrapped and shot) should give a better idea. Even so, the end result (Table IV) is influenced by the relative proportions of the two sorts of data. We cannot be sure that the data we happen to have are well balanced. Nor can we make a precise comparison between Table IV and the data which were derived in a similar manner for prairie chickens⁷ because there are relatively many more hunter-kills among the sharp-tail data. Despite these reservations, however, the two sets of data do show that local movements of the two prairie grouse in Wisconsin are on about the same scale:

Retaken	162 sharp-tails	157 prairie chickens
In place only	38%	35%
Within 2 miles	81%	81%
More than 3 miles	12%	13%
More than 5 miles	10%	8%

It might be better to limit the comparison to autumn retakes since all but one or two of these, for both prairie chickens and sharp-tails, are hunter-kills:

Retaken	94 sharp-tails	29 prairie chickens
Within 2 miles	69%	48%
More than 3 miles	21%	38%
More than 5 miles	17%	34%

⁷ In the comparisons which follow the prairie chicken data are from Hamerstrom and Hamerstrom, (1949).

The small number of prairie chicken retakes weakens the comparison, of course. Nevertheless, we are convinced from other field data that prairie chickens really are somewhat more mobile than sharp-tails during most of the year.

In winter, individuals of both species were most often retrapped in place. Only six of 19 sharp-tails were retaken anywhere else, and only 16 of 79 prairie chickens. Here again, although the samples are very small, the prairie chickens show somewhat longer movements—up to 4.5 miles as compared to 2.3 miles for sharp-tails. Some birds of both species were retrapped in place in the same and later winters, sharp-tails more often than prairie chickens; as individuals of both species often became repeaters and were retrapped in place over and over again, we list only the *last* time that they were recaptured as a basis for comparison:

	Retrapped in place for the last time in:	75 sharp-tails	71 prairie chickens
Winter of banding		54	67
2nd winter		20	2
3rd winter		1	2

Those sharp-tails which will accept grains in winter tend to be easier to trap than prairie chickens. Large packs of prairie chickens are especially hard to trap. Therefore one cannot say, from these data, that sharp-tails are much more likely than prairie chickens to return to the same feeding places year after year: the apparent trend in that direction may really be a reflection of trapping differences. It is perhaps enough to say that some individuals of both species do go back in later years, and that band returns have shown this behavior more clearly in sharp-tails than in prairie chickens.

We know when 166 sharp-tails, of the 167 in Table IV, were last retaken. Seventy-eight per cent were retaken within the first year after banding (i.e., before the next winter), only three birds during the third year. On a scale of 100 the rate of regression is:

	Banded	2nd yr	Retaken		
			3rd yr	4th yr	5th yr
Sharp-tails	100	20	2	0	0
Prairie chickens	100	16	9	1	0

Thus, these figures suggest that the population turn-over period for small samples of both sharp-tails and prairie chickens may be roughly three to five years. Ammann's (1945) findings indicate a somewhat longer turn-over period for sharptails. He lists 50 recoveries of sharp-tails which were transplanted in Michigan, all wild birds: of these, 62 per cent were retaken within the first year, 28 per cent in the second, six per cent in the third, and two per cent each in the fifth and seventh years.

MOVEMENTS OF TRANSPLANTED SHARP-TAILS IN WISCONSIN

During the winter of 1932-33 Schmidt transplanted a number of wild-trapped sharp-tails. All were caught at one station in the Town of West Remington, Wood County. They were released as follows:

Wood County, Town of East Remington	7 ♂ ♂	8 miles away
Portage County, Town of Pine Grove	17 ♂ ♂ 5 ♀ ♀	35 miles away
Adams County, Town of Richfield	15 ♂ ♂ 4 ♀ ♀	31 miles away

Ten of these bands were turned in by hunters during the open season of 1933 (Table V). No bird was shot at the point of capture, nor on a direct line between this place and the release points. However, of the seven which had moved more than a mile from the release point, six had gone within 90 degrees or less of the homeward direction. Only one was closer to home than to the release point.

TABLE V.—Movements of transplanted sharp-tails.

	Distance between points of release & return: miles								Total
	0-1	1-2	2-3	3-4	4-5	15-16	23-24	26-27	
Number of birds	3	1	1	1	1	1	1	1	10

Comparing these returns with the first-year hunter-kill returns for birds released in place, it is plain that the transplanted birds moved farther:

	Transplants	In Place
Moved 0-2 miles	40%	71%
Moved 0-5 miles	70%	86%
More than 5 miles	30%	14%

The Michigan Department of Conservation has released over a thousand wild sharp-tails in sharp-tail-vacant habitats in the eastern end of the Upper Peninsula and in the northern half of the Lower Peninsula. The birds came from the western part of the Upper Peninsula and from Wisconsin and Alberta; they were banded and released in 20 localities between 1937 and 1944. Ammann (1945) has reported on this program. He found that "there seems to be an innate tendency for Sharptails of both sources [i.e., Michigan and Wisconsin, as compared with Alberta] to wander," and that "the birds apparently dispersed in all directions" from the release points (p. 21).

A COMPREHENSIVE SURVEY OF SHARP-TAIL MOVEMENTS

INTRODUCTION

In the United States and southern Canada the sharp-tail was originally a bird of the prairies and plains and their fringing brushlands. *Campestris*, for many years the subspecific name of all sharp-tails east of the Rockies and south of the Canadian forests, is a reflection of this adaptation to open country. But north of the snow line, at least, they were prairie and plains birds mainly during the warmer months—the breeding and rearing seasons. They moved into a different sort of cover for the winter. Bendire, generalizing for *campestris* [= *campestris* + *jamesi*]⁸ spoke of this alternation between habitats when he wrote (1892: 102, quoting George Bird Grinnell; see also G. B. Grinnell, 1910: 256): “. . . there is the very greatest difference in the habits of the bird in summer and winter. As soon as the first hard frosts come in the autumn the birds seem to take to the timber, and begin to feed on the buds of the willow and the quaking aspen.”

It must have been an impressive sight, a hundred years ago, to see the sharp-tails move from the prairies to their winter quarters. No one knows how large the moving packs were, nor how far they went. The movement was so conspicuous, on so large a scale, and apparently so regular, that many who saw it called it migration. Thus Judd (1917: 15) wrote of North Dakota: “The most abundant of the Grouse family and seen the year round, but the winter birds are thought to be those raised farther north. There appears to be a marked migration of this sub-species.” Many authors have recorded sharp-tails as winter visitors without, however, using the term migration. For example Johnson (1934: 8) says that near his home in southwest Minnesota, during the period 1889-1902, sharp-tails “began to arrive . . . about the first of October and departed the following spring, having disappeared about the time the prairie chicken returned. I never found any evidence of the sharp-tails nesting in the general territory here under consideration.” Some authors have used such in-between terms as “partially migratory” or “migratory to some extent.” A few, while recognizing the scope of the seasonal movements, have nevertheless called the sharp-tail a resident bird. Some, like us, have seen this movement only on a small scale. Most authors have simply listed the sharp-tail as resident without mentioning such a movement. Emigrations have occurred, reflecting, perhaps, the influence of unusual population density upon this basic pattern.

Since there is such a wide variety of opinion on the nature of—or at least the name for—sharp-tail movements, and since these references are scattered through so many sources, it seems worth while to bring together in one place all that we have been able to find. Through correspondence with other ornithologists we have been able to add to the data for some areas, and especially to add present-day information for comparison with the earlier literature.

⁸ We are following the nomenclature of Ridgway and Friedman (1946).

These data, both published and original, are summarized in the Appendix. We will try to analyze them under the captions which follow.

MIGRATION

With respect to migration, the general sense of these records seems to boil down to this:

(1) Fifty to a hundred years ago, when sharp-tails were on their original range, there were conspicuous seasonal movements between breeding and wintering areas. The literature strongly implies that these movements occurred annually, but we have nowhere found a direct statement to that effect.

(2) Some authors say that the move to winter quarters was toward the south, but they give very little actual evidence to show the direction of the movement. Krefting (1941) says that Minnesota sharp-tails move *northward* for the winter. Most authors, however, do not specify the direction of the movement.

(3) The extent of these movements cannot now be determined with any degree of accuracy. Some populations evidently moved farther than others. The movement was never, so far as we can tell, long enough to take northern birds south of the snow line. Altitudinal "migration" is a possible exception to this. However, Marshall and Jensen (1937) found that altitudinal movements in Utah were oriented toward cover types: in winter—with snow—the birds moved into "high brush" cover types, whether such cover was to be found up-slope or down. In North Dakota there are "varying annual movements . . . from the plains into the Turtle Mountain region" (Roy N. Bach, letter), a movement up-slope into a brushy district for the winter. Cooke (1900: 203) records that sharp-tails breed in Middle Park, Colorado, but not above 7,500 feet; in winter, however, they have been seen up to 9,500 feet. Cary (1909), on the other hand, speaks of a downward movement of as much as 3,000 feet in severe weather on Lone Cone, in Colorado. There are (or have been) down-slope movements from the plains into their brushy ravines, coulees, and river bottoms, but these wintering places may have even more snow than the wind-swept uplands. Sharp-tails moving down-slope are most likely to have found considerably less snow in parts of Montana, Colorado, Washington, and California, but such examples are definitely in the minority.

(4) There is little reason to think that the winter range was, in general, much milder climatically than the summer range, nor that the breeding range extended significantly farther north than the winter range. The ranges of the two races of the Northwest, in Alaska and northern Canada, may prove to be exceptional in this respect, however.

(5) Snyder (1935a: 13-14) has summarized the situation for *campestris* [= *campestris* + *jamesi*] in these words: "Flocks leave the nesting territory for areas more completely and extensively covered with trees and shrubs. This is apparently an alimental necessity or convenience, since food can be obtained

more abundantly and readily above ground than on the ground after snow falls. There is, apparently, no obvious north-south movement which can be interpreted as a marked climatic change of residence for this form of the sharp-tailed grouse." This summarization seems to us to fit the seasonal movements of all sharp-tails except, perhaps, *caurus* and *kennicottii*, of which we know too little to have an opinion.

MOVEMENT TO WOODY COVER FOR THE WINTER

Extent of movement.—This is not the place to argue whether or not sharp-tails are migratory. It is enough to remark that large-scale seasonal movements between breeding and wintering ranges once were common. The scale of these movements has since been tremendously reduced, at least within the United States. In the eastern part of their range sharp-tails have long since been driven from the long-grass prairies. They have been pushed north into the small openings of the "Cut-over"—its bogs, marshes, old fields, and old burns. In this environment, most of which is new for the species, sharp-tails are always close to woody cover, as we have noted earlier. A movement of a few hundred yards will generally suffice. Sharp-tails have nearly disappeared from the southern and western parts of their original range in the United States. In some places they are gone entirely, as in Kansas and Oklahoma. West of about the 104th meridian, where they do persist they are mostly found in rather small numbers in scattered "islands" of suitable habitat. With the possible exception of a very few localities, a mass movement there is out of the question: there are not birds enough. There are probably more sharp-tails in the Dakotas and Nebraska than there are anywhere else in the country. Even there plow and cow have ripped up and chewed down much of the original nesting range. Sharp-tails are now largely confined to the "leavings"—haylands, the sandhills, the brakes and coulees, and the brushlands. As a result, the present nesting range is often close to the brush or actually in its edges. As in the Lake States, the movement to winter cover is now a short one.

Ruel Janson (letter) has given us an especially fine account of the situation in South Dakota: "The chief sharp-tail range of the state is, and apparently was in the early days, most of the area west of the Missouri River. This is a typical 'plains' area with grassland predominating. However, it is a much rougher area than the portion of the state east of the Missouri owing to the five rivers, roughly parallel to each other, that enter the Missouri from the west. These, and their tributary creeks, have carved rather deep canyons in the relatively high land through which they flow. The stream bottoms and the tributary 'draws' are timbered in varying degree with cottonwood, bur oak, green ash, American elm, and boxelder. Patches of brush occur in draws, north slopes, and on stream bottoms. These are composed of chokecherry, plum, buffalo berry, skunkbrush, and snowberry. Extending back, sometimes for several miles on each side of the larger streams, are rough 'brakes' areas ['more or less brushy'] which slope upward to extensive plateau areas forming

the divides between drainages. These flat areas were once covered chiefly with grasses, but are now cultivated and pastured rather intensively. Before these areas were cultivated, they were probably important to the grouse as nesting habitat, for portions of such areas that still remain in a natural condition are used by them for nesting. Increasing use of the flat areas for farming and grazing has apparently forced the sharp-tails to nest more in 'brakes' than they originally did.

"According to old-time residents, grouse left the uplands after the first snows, and wintered on the river bottoms. This is still true to some extent, although agriculture has modified the movement somewhat. As nesting habitat now lies more in the 'brakes' than formerly, the movements to and from winter habitat on the river bottoms is considerably shortened in some areas. The grouse that I have observed on the river bottom areas during the past two winters did not roost there, but flew back into the 'brakes' in late afternoon to roost in the grass or snowdrifts. These flights varied from a few hundred yards up to about two miles. . . .

"As you have probably gathered from the preceding discussion, nesting and wintering habitats overlap considerably, especially where the uplands are farmed. However, there is an area near Mobridge, and extending west from the Missouri River about ten miles, where I have noticed seasonal movements probably comparable to those in areas where agriculture has not interfered. There is some farming in this area, but as most of it is adjacent to the river, it does not restrict the nesting habitat on the uplands. There are several dancing grounds in this area, varying from two to 10 miles from the river. I am reasonably certain that all the grouse in this area move to the river in the winter, where they feed in fields on the bottoms, as well as in the trees there. However, they fly back into the 'brakes' from one to two miles to roost. In this particular case, the seasonal movement involved would be almost none for those birds nesting nearest to the river, and up to 10 miles for those nesting farther out."

Even in Canada, sharp-tails have suffered much the same loss of prairie and plains nesting habitat and show the same great reduction in numbers in the intensively farmed grain belt. Consequently, even there the old-time "migration" seems also to have died out. At least, we have not been able to find any recent record of it. The present center of abundance for *campestris* and *jamesi* is in the "Parkland"⁹ belt which borders the prairies. We travelled for several hundred miles through the Manitoba Parklands in 1939 and 1948, and found the sharp-tail range there very like that in the Lake States, at least to the extent that open cover and brush are closely interspersed. Here too the movement to winter cover is probably a short one.

It would seem, then, that the old-time large-scale movement between breed-

⁹ This belt has been called the "Parkland" by Lewis, Dowding, and Moss (1928), the "Aspen Parkland" by Bird (1930), and the "grove-belt or poplar forest" by Snyder (1935b). Dice (1943) considers it simply a transition strip and not a separate biotic province.

ing and wintering ranges—the “migration” of the earlier ornithologists—has utterly ceased to be. This generation will never see it.

Nevertheless, the shift between summer and winter habitats still persists, even though in miniature. *Basically, it is the seasonal alternation between habitats which seem important, rather than the distance travelled in accomplishing it.* This alternation has been recorded in many places (Appendix). We have seen it, and so have others, in Wisconsin and Michigan; including both early and recent records, it has also been seen in Minnesota, North and South Dakota, Nebraska, Kansas, Montana, Colorado, Idaho, Utah, Washington, California, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia. These records include almost every State and Province in the past or present range of the three southern races of the sharp-tail. According to Snyder (1935a: 14) the northeastern race *phasianellus* makes “a similar seasonal movement.” In the far Northwest—Alaska and Athabasca-Mackenzie—seasonal movements have been reported for the two remaining races, *caurus* and *kennicottii* (Preble, 1908; Bent, 1932; Snyder, 1935a). Very little is known about these movements, however, and we cannot be sure that they are comparable to those of the more southerly races.

Parenthetically, descriptions of sharp-tails' winter habits often point out that the birds spend a great deal of their time in the trees, off the ground. Hearne (1795), in one of the earliest first-hand accounts of sharp-tail behavior, commented upon this trait. Seton (Thompson, 1891: 520) has given what is perhaps an extreme example: “During the summer the habits of the [sharp-tails] are eminently terrestrial . . . but the first snow makes a radical change. They now act more like a properly adapted perching bird, for they spend a large part of their time in the highest trees . . . evidently at this time preferring an arboreal to a terrestrial life.” Curiously enough, Cooper and Suckley (1859: 223) wrote that sharp-tails “shun high grounds and forests entirely” in Washington Territory, but on the same page added: “When heavy frosts and snow began, near the 49th degree, they would fly to the tops of the trees in the early morning to warm themselves, often ascending to the tops of pines a hundred feet high.”

It would be a mistake, of course, to assume that the pattern of alternating between habitats is rigid and unchangeable. Exceptions do seem to occur. Some of these are perhaps more apparent than real but some, because of special local conditions, are real enough. The differences are mainly of two kinds: (1) In some areas sharp-tails use woody cover in summer more than they do in others; and (2) in some areas sharp-tails keep more to the open in winter than they do in others. The net effect of either of these modifications is to level off, in varying degree, the difference between summer and winter habitat. Each of these exceptions seems to have occurred under original conditions. Each has occurred—or has been intensified—as a result of civilization.

Using brush in summer.—Even under original conditions, the three southern races of sharp-tails were not wholly birds of the prairies and plains. Their range extended into the Parklands on the north, and to some extent into the

transition zone between prairie and forest on the east. To a degree which we do not fully understand it included some rather large areas of interior brushlands. There is reason to believe that sharp-tails went into woody cover to some extent in summer in these places. For example, in parts of northern Illinois and southern Wisconsin, about 1840, sharp-tails were locally called "burr oak grouse" because they were found "always frequenting the timber" (S. C. C., 1879: 705; see also Schorger, 1944 and 1948). In the vicinity of Salt Lake City, Utah, sharp-tails had their "center of abundance" in sagebrush plains and mesas (Ridgway, 1877). They were one of the characteristic birds of the sagebrush on the plains of south-central Idaho (Merriam, 1891) and in the Yakima Valley of Washington (Kennedy, 1914). Thorne (1895: 213) noticed that cover preferences differed somewhat from place to place: sharp-tails near Fort Keogh, Montana, seemed "to frequent the vicinity of trees and bushes more than the Dakota birds." Near Fort Klamath, Oregon, Bendire (1892: 100) found sharp-tails "keeping close to, if not in the edges of, the pine timber throughout the year." All of these examples are so lacking in detail that one cannot piece together the whole story. The birds may have made minor shifts between the more open and more dense parts of their local environment, but grossly, at least, there seems to have been less difference between summer and winter habitats than there was in the case of the birds which nested on the prairies and the short-grass plains.

Some of the grassland sharp-tails had access to brush in summer. The rivers and streams which finger through the plains commonly have timber and brush along their courses, except in their driest parts. Their tributary ravines and draws are likewise brushy. The sharp-tails which lived closest to these water-courses made use of their brushy fringes even in the early days. In the region of the Red, Pembina, and Souris Rivers, Coues (1877: 417-418) saw them "mostly in the underbrush along the streams" in summer. It was only later in the autumn that they "strolled in company far out on the prairie" to any marked degree. It is plain that they shifted into the brush for the winter, for: "They haunt the interminable ravines along the Missouri, making away from the river-bottoms in search of food, but mostly returning at evening to roost in the trees." In another paper dealing with the same region he adds that in winter the birds "hug the timber, and sometimes, on lowering or stormy days, remain motionless on their perches for hours together" (1878: 632). Allen (1872: 141, 144) found sharp-tails "common along the streams" in spring and summer near Fort Hays, Kansas, and comparable examples are given by G. B. Grinnell (1876), Abbott (1880), and Lincoln (1925). Snyder's experience in the Rainy River District of Ontario, in the summer of 1929, is rather similar (1938: 186): "Much open country and muskeg was reconnoitered in search of this species but it was found only adjacent to farmlands where scattered trees, clumps and thickets of saplings and shrubs, fallen trunks and brush, broke an otherwise open landscape."

It is possible that Lake States sharp-tails go into the brush in summer more than we realize. Baumgartner (1939: 488) says that in northern Mich-

igan, in late May and June, the males and those females which are not nesting spend "most of the day" in shady places along swamp edges or, less frequently, in upland thickets. In early August, however, they are "commonly found in more upland, open situations," and "heavy snows and stormy weather in December and January" drive the birds into white birch and aspen thickets for the winter. Here again there is a shift from the open herbaceous cover of late summer and early autumn to woody cover for the winter, although in our experience the shift has come long before the first snows. The main difference lies in the use of woody cover by part of the population in summer. We suspect that shade is sometimes sought where it is conveniently available in summer, and we occasionally found it so on the Necedah area; but we doubt that there is a summer movement to shading cover on anything like the scale of the shift to winter cover. We must add, however, that less is known about sharp-tails in midsummer than at any other time of year.

Some of the foregoing examples have been drawn from a time when civilization had already affected sharp-tail habitat. A few, however, are descriptions of original or near-original conditions. Janson's discussion of South Dakota, quoted above, clearly shows that farming and grazing have forced sharp-tails there to nest in the brush to a much greater extent than they did before. In the Lake States, where the original nesting range has been even more thoroughly destroyed, sharp-tails are now often thought to be almost entirely birds of the brush. This is partly because the openings which the birds use in spring and summer are often small and scattered in large areas which are mainly—and conspicuously—brushy in character. But it is also true that sharp-tails are found as remnants on ranges whose old openings have been partly, and sometimes largely, taken over by encroaching brush. To that extent they are truly "brush birds" even in summer. However, by the time the invading brush has become as thick as winter cover, and there is no thin cover left, sharp-tails have disappeared. Ligon (1927: 127) found a similar tolerance of thin brush as a substitute for open herbaceous cover in New Mexico. There the sharp-tail "must have rank grass for dwelling and breeding places, but due to excessive grazing by domestic animals, the isolated patches of suitable cover to which it often is limited are now inadequate for its needs. Fortunately, however, about the draws and canyons that cut the mesa rims small oaks or shinners furnish an excellent emergency cover." In a letter he has added: "... the birds have found a substitute habitat in the brush and shinners. In fact I am confident that the sharptail would not have survived on Johnson Mesa had it not been for marginal brush cover when cattle destroyed their preferred habitat—the rank growing grass."

If the two northwestern races are truly birds of the forest, as they are sometimes considered to be, how has such an adaptation come about? Is it, perhaps, simply an extension of the ability to tolerate thin brush and open woods as a substitute for open herbaceous cover? Or perhaps the matter should be put the other way: have the southern races developed an ability to substitute brush for forest during the winter, and to divorce themselves from

either during the warmer part of the year? A better understanding of the northern races, and of the intergrading populations, might give the answer.¹⁰ In any case, it would be extremely valuable to find out *precisely* to what extent the southern races will tolerate thin brush or open woods as a substitute for open herbaceous cover during the breeding and rearing periods.

Using open cover in winter.—Just as some sharp-tails use woody cover in summer more than others, so also do some keep more to the open in winter than most. This is perhaps especially true in the West. For example, sharp-tails in California were found “even occasionally among small trees, though never in heavy timber” (Grinnell, Bryant, and Storer, 1918: 561). L. R. Dice has told us that although he has seen sharp-tails go to the cottonwoods along streams in winter in Washington, the birds went only into the edges of the wooded strips at most, and spent most of their time in the open grasslands. These examples suggest that the brush-frequenting habit is very poorly developed or almost absent in comparison with the behavior of sharp-tails farther east, perhaps in response to an environment with little or no snow. Baird, Brewer, and Ridgway (1874: 438) seem to deny or to overlook the more customary shift to woody cover in winter, for they wrote: “It seldom goes into the timber, always remains close to the prairie, and never retires into the depth of the forests.” It is probably significant that although this statement occurs in their general account of all the United States races, most of the examples in that account were drawn from authors who had written of the far West.

The effect of winter grains on movement.—Wintering habits, like summering habits, have been modified to some extent by agriculture. Sharp-tails first began to take advantage of cultivated fields a good many years ago. Cooper and Suckley (1859: 224) had this to say of sharp-tails in the West in the 1850's: “In certain places they are in great numbers in the autumn, congregating in large flocks, especially in the vicinity of patches of wild rye, and more recently near settlements where there are wheat stubbles.” It is probably safe to say that sharp-tails have been going to the stubbles in autumn ever since. Where they are conveniently to be had, grains seem to have become a standard item of the fall diet. Sharp-tails began to eat grains in winter at an early date also. Lord (1866: 304) wrote: “At the Hudson's Bay trading-post at Fort Colville there were large wheat-stubbles; in these, after the snow fell, they assembled in vast numbers.”

The influence of this new source of food on winter habits is not easy to

¹⁰ The northern races may not be forest birds, in reality. Snyder (1935a: 32) says that *phasianellus* “in habits and behaviour, is still an open-country bird; it still attempts to be a ‘prairie dweller’ in the openings of the forests of the north.” Of the northern races in general Swainson and Richardson wrote (1831: 361): “. . . found throughout the woody districts of the fur-countries, haunting open glades or low thickets on the borders of lakes, particularly in the neighbourhood of the trading posts, where the forests have been partially cleared.” L. R. Dice told us that the black spruce forests in which he saw sharp-tails in central Alaska were actually open stands of widely scattered low-growing trees—hardly forest at all, in the usual sense of the term.

assess. We have already shown that in Wisconsin a large part of the sharp-tail population stops eating grain in mid-winter. In an effort to learn how general this mid-winter refusal of grains may be, we have written to a number of sharp-tail banders in other areas in Wisconsin and in other states¹¹ with the following results: In Minnesota, Michigan, and Wisconsin, sharp-tails have been found to feed extensively on grains in autumn and early winter, and again in late winter and early spring. Many birds refused available grains for about a month in midwinter, making trapping much more difficult during this period; nevertheless, some continued to eat grains. In most cases midwinter catches were smaller, but trapping was still worth while. By contrast, in North and South Dakota sharp-tails have *commonly* continued to eat grains as long as they were available. Midwinter has been the best trapping period. This is a strange contradiction in behavior, and one which has not been explained as yet. Despite this difference, the consensus in all five states is that sharp-tails do not need grain in winter. Even those birds which do eat grains probably spend the winter, in many instances, in essentially the same places and in much the same manner as they would if there were no grain to be had.

This attitude of "take it or leave it alone" shows up in other ways. There are many places in the northern part of the Lake States where there are large year-round populations in wholly grainless areas. In Nebraska the main sharp-tail range is in the sandhills, north of the Platte River, where prairie chickens also nest. In winter the chickens move into the agricultural lands to the southeast of the sandhills, where grain is available. The sharp-tails, however, move locally into the brush for the winter and do not follow the chickens to the grainfields (Mohler, 1944 and letter).

On the other hand, winter grain does seem to be important to sharp-tails in some places. Ligon (1927, 1946, and letter) considers that wheat is helpful to sharp-tails in winter in New Mexico. Dawson and Bowles (1909: 598) say that sharp-tails in Washington changed their wintering habits as the result of the introduction of grains: "In the early days [the sharp-tail] was partially migratory in habit, spreading out upon the sage-brush stretches and rye-grass plains in spring and summer, but resorting to the aspen groves and timbered draws in winter. As soon, however, as cultivation assured support in winter, the birds began to maintain their place in the open wheat-fields, or visited the haystacks and the farmyards." Dawson describes the same change, in exactly the same words, in writing of the sharp-tail in California (1923: 1601). In an earlier page he characterized the sharp-tail in Okanogan county, Washington, as "an invariable accompaniment of stubble-fields, and an habitué of grain stacks" (1897: 173).

Apparently then, in some places sharp-tails have been able to winter in the open because cultivated grains have been introduced into their environment. The same thing may be happening now on the Manitoba prairies: "During the

¹¹ Wisconsin: W. H. Schunke, D. W. Mather. Michigan: G. A. Ammann, D. W. Douglass. Minnesota: Jack Manweiler. North Dakota: M. C. Hammond, S. E. Aldous. South Dakota: Reuel Janson. See also Schmidt, 1936; Barton *et al.*, 1938; Aldous, 1943.

past two winters we have been feeding Upland game birds here in Manitoba, and this feeding has been taking place all across the prairie part of the province. We have no indication of their moving Northward into the park lands or scrub country for shelter during the winter months, nor their leaving these areas for the open prairie during the summer" (G. W. Malaher, letter). Mr. Malaher has been careful not to impute a cause and effect relationship here, and so are we. Nevertheless, the absence of a pronounced seasonal shift makes an interesting contrast to the "partly migratory" movements of Seton's day (see Appendix). The former "migration" into northwest Iowa for the winter also has tantalizing implications. What brought them there? Northwest Iowa would seem a more likely source of winter grain than of browse and woody cover. Here again the known facts are no more than suggestive. We do not know the explanation.

To summarize: (1) Some sharp-tails live their whole lives beyond the reach of cultivation, and are not affected by it at all. (2) Some eat grain as long as it is available and then switch to browse. (3) When grain is available all winter, some sharp-tails continue to eat it, but some refuse it in mid-winter and return to it toward spring. (4) Very often, sharp-tails have simply added grain to their winter diet without changing their winter habits to any marked degree. (5) However, by accepting grain as a winter food, some sharp-tails seem to be able to winter in the open instead of in the brush.

PACKING

Twice yearly, despite a certain amount of local nonconformity, sharp-tails tend to shift from one kind of habitat to another. Occasionally in late winter, and consistently in the autumn and early winter, they gather into packs. Lord (1866: 304) has described packing especially vividly, as he saw it west of the Canadian Rockies: "After nesting-time, they first appear in coveys or broods about the middle of August; the young birds are then about three parts grown, strong on the wing, and afford admirable sport. . . . About the middle of September and on into October they begin to pack; first two or three coveys get together, then flock joins flock, until they gradually accumulate into hundreds. . . ." At Fort Lapwai, Idaho, sharp-tails "gathered into large packs during the late fall and winter, frequently numbering two hundred and more. These kept together until about the beginning of March, when they commenced to break up" (Bendire, 1892: 99). We have seen packing in Wisconsin and Michigan. It has, in fact, been recorded practically everywhere that sharp-tails occur. Many of the references which we have already cited contain material on this habit. Additional sources are: Ammann (1946), Bendire (1889), Bonaparte (1828: 39), Brooks (1898), Brooks and Cobb (1911), Coues (1893: 868), Hayden (1863), Janson (1947), and Wilson and Bonaparte (1876: 380). Packing is often described in the sporting literature; see for example, Cantwell (1874), and Sandys and Van Dyke (1924: 195).

EMIGRATION AND RANGE EXTENSION; INFLUENCE OF NUMBERS

Emigration.—So far, we have been speaking of the usual run of sharp-tail movements. Even the so-called migrations apparently were usual in their day. There remain a few movements of an unusual sort—unusual, that is, in the sense that they do not happen as often, or as regularly, as the foregoing. The first of these is emigration.

At times in the past sharp-tails have embarked upon particularly spectacular mass movements in autumn and winter. These movements have been many years apart in time. They have had a generally north to south direction. So far as known, they have not been followed by a return to the north the next spring. They seem not to have resulted in permanent establishment of new range within the areas of invasion, although sharp-tails have persisted for a few years in a few localities. In all of these particulars, these movements agree with Heape's (1931: 29-31) definition of mass emigration.

A recent one, which occurred in Ontario and Quebec in 1932, has been studied more thoroughly than any other. Déry (1933) made a preliminary report on the matter. Snyder (1935a) has discussed it in detail, along with a review of two earlier emigrations which took place in 1896 and 1865. According to Snyder (pp. 15, 32) only *phasianellus* is known to emigrate. Schorger (1944) suggests that the flight into Wisconsin in 1865, which he calls a migration, may have consisted of *campestris*. Rowan (1948: 7) says: "Similar movements on a smaller scale have taken place also in the west [of Canada] although they have never been put on record." He described (p. 5) a mass flight in the Chip Lake district of Alberta in 1942; it may have been such an emigration.

Mass emigration is something which can be seen directly. Moving flocks have been watched as they passed by, and especially during the emigration of 1932, the progress of the "front" was recorded in some detail. Mass emigration is obviously the sum of long-distance movements of many individual birds. In fact, all of the movements which we have discussed are essentially individual movements in which greater or lesser numbers of sharp-tails take part.

Temporary expansion of range.—By contrast, there are also movements which are characteristic of populations rather than of individuals—movements in which one cannot see the individual components directly and which can be detected only through year-to-year changes in the distribution of the species. At times of cyclic abundance, for example, sharp-tails commonly spread out into inferior country; they then retreat during the next low. The outward spread is a slowly changing frontier, in comparison with the sudden rush of an emigration. Thus Snyder (1935a: 13), speaking of the year or two just before a cyclic high, says that "the population of northern sharp-tailed grouse somewhat expands its nesting territory southward when numerical pressure is present." Similarly, Rowan (1948: 8-9) says that when upland game birds "approach the peak they commonly move into areas in which permanent estab-

lishment seems quite unlikely. Sharptails will move onto the prairies . . ." which, in Alberta, are now very poor sharp-tail habitat (letter).

Range extension.—These slow-moving, relatively short-range outpushings usually die out just as completely as emigrations do, and the permanently occupied range then shrinks back about to what it was before. However, that is not to say that the range is absolutely fixed and unchangeable, for sharp-tails have occasionally been able to extend their range into new areas. The northward shift in Wisconsin and Minnesota are examples. The term "northward shift" is to some extent a misnomer. It is true that the center of abundance shifted northward when the birds lost their prairie range and spread through the "Cut-over." It is also true that there were already some sharp-tails in the natural openings of the forest. The great increase which followed the opening up of the "Big Woods" may have come about as a spreading out from the already existing centers. But whatever the direction and the source, there certainly was a spread into new range. More recently, sharp-tails have spread completely across northern Michigan. They presumably "entered the west end of the Upper Peninsula in large numbers in the wake of extensive fires that swept up from Wisconsin before 1920" and had reached Alger county by 1939 (Baumgartner, 1939: 485). In 1943 they still had "a few miles to go" to reach the eastern end (Douglass, 1943: 8), although the advance was being helped along by transplantings of wild birds. One of these plantings was made on Drummond Island, the easternmost tip of Michigan, in 1941. Sharp-tails have rapidly increased on the island since then (Ammann, 1947), so that the final stage of the natural spread has been obscured. It seems likely, however, that the spread was essentially finished (in Michigan) by 1941—a spread of almost 200 miles in about 25 years.

There are other examples of range extension. In Alaska the range of *caurus* now includes Tanana, Fairbanks, and the north fork of the Kuskokwim (Ridgway and Friedmann, 1946: 192). Dice (1920: 180) found sharp-tails in these places in 1911-12, and noted: "Hunters claim that this species has only within the last few years appeared in these regions, never having previously been found so far west." In Canada, *campestris* appears to have spread from Manitoba into western Ontario after the building of the Canadian Pacific Railroad (Fleming, 1906; Baillie, 1947). It is perhaps still spreading eastward in Ontario, possibly as a continuation of the earlier movement and possibly also involving spread from northeastern Michigan, but the whole story is not yet known.¹² Altogether, it seems likely that successful range extension is most apt to occur when an expanding population, near a cyclic high, strikes an area which happens to be suitable and unoccupied, such as a recent burn. It was fire which opened the way for sharp-tails to come into Michigan's

¹² In 1913 Soper (1919) found sharp-tails 175 miles farther west in Alberta than Spreadborough had in 1898, and adduced a recent extension of range. However, later information lead him to think that the birds had been present in the west for many years, possibly even before the date of Spreadborough's record (letter, 1948).

Upper Peninsula, for example. Further, the subsequent eastward spread across the peninsula was halted, or at least markedly delayed, during the cyclic low between 1933 and 1939, while it picked up speed again as the high of 1942 was developing (Baumgartner, 1939). The westward spread in Alaska seems also to have come at a time when sharp-tails were on the increase in the north. There are no population curves for Alaska itself, but sharp-tails were abundant in British Columbia between 1911 and 1915 (J. A. Munro, letter) and rose to a cyclic peak in Manitoba in 1913 (Criddle, 1930); since populations of most cyclic species are synchronized within a year or two of one another from place to place across the northern parts of this continent, it seems significant that the westward movement in Alaska was reported "within the last few years" before 1911-12 (Dice, 1920: 180).

Effect of population density on movements.—All three of these movements—mass emigration, rhythmic expansion and contraction of the range, and successful range extension—are thus influenced by population pressure. Annual movements are probably also affected by density. A large pack may well have to move farther than a small one to find good wintering grounds, for example. In fact, all of these movements may differ one from another only in degree, not in kind. Snyder (1935a: 34) has already suggested that the "usual" southward movement of *phasianellus* (the annual movement to winter cover) might develop into an explosive mass emigration through no other cause than the psychological effect of sheer numbers: "Once a pronounced flight was under way [with smaller flocks decoying to it from the ground] it would grow by developing its own immediate cause."

We are struck by what seems to be a curious contradiction between Snyder's findings and ours. In building his theory of the way in which sharp-tail emigrations may come about, he says (p. 34): "At this season [autumn] there are apparently no territorial ties to hold birds to a given spot." If we may substitute the concept of home range for that of territory (simply to keep clear of the question of *defense* of an area), we have found that in Wisconsin and Michigan sharp-tails commonly do have definite ties to a familiar place. Autumn dancing at the places which are used in spring is another evidence of ties to a given spot in autumn. Two questions come to mind: Is it perhaps the absence of such ties which predisposes *phasianellus* to emigrate? But Rowan (1948) has said that there are emigrations in Alberta, and he has also told us (letter) that autumn dancing occurs there on the spring dancing grounds. Or might it be that autumn place-ties are developed to some degree, or in some individuals, even in those populations which emigrate, and that it is those very ties which keep sharp-tails from emigrating more often than they do? Such ties might prevent Snyder's decoying effect from operating until a year in which the moving flocks were so large that their attraction was strong enough to uproot those birds which had already settled into autumn quarters. The question cannot be answered until more is known about the usual movements in the north.

DISCUSSION

Sharp-tails have a wide—if spotty—distribution. The habitats in which they live differ considerably from east to west and from north to south. Their habits also differ somewhat from place to place. There are many partial descriptions of sharp-tail life history and ecology, but few intensive studies. Especially little is known of the two northwestern races, *caurus* and *kennicottii*, and rather little of *phasianellus* on its breeding range. Thus it is not always easy to relate what we have seen in Wisconsin and Michigan to the habits of the species as a whole. There seem to be, withal, some fundamental similarities in the movements of sharp-tails in widely separated places.

For example, sharp-tails seem to be rather sedentary during most of the year. Schmidt's findings (Leopold, 1933: 76) and the band retakes in Wisconsin, our field observations, the studies of O. S. Lee (1936) and Marshall and Jensen (1937) in Utah, Baumgartner (1939) in Michigan, and Aldous (1943) in North Dakota, all tend to show that daily cruising radius is generally on the order of a mile or two, and often less. Granted that there is more to be learned here, a general pattern does seem to exist over a considerable part of the range of the species.

Twice yearly, however, this simple pattern goes by the board. In late autumn or early winter sharp-tails move from one kind of cover to another, and draw together into packs. At the end of winter they move back to their summer range, even though the distance is often very short, and the winter packs disperse. Both sorts of behavior—packing and the seasonal shift—require movement. These movements are closely related; certainly in point of time, perhaps also in causation.

It is these two movements that we wish especially to discuss.

Why do sharp-tails move into the thickets and woods for the winter? It is easy enough to see that the open, wind-swept plains must have been short of both food and cover before the coming of the grainfields. Even the prairies may have offered poor forage for a bird as large as the sharp-tail, especially when there were so many to be fed. In some districts the prairie chicken also had to move out for the winter. In the Mississippi Valley the prairie chicken hens once migrated "as regularly as the Canada Goose" (Cooke, 1888: 105). It would seem that this migration was closely tied to a scarcity of winter food, for the movement was markedly cut down when the corn of the early settlers became available (Spurrell, 1917; E. B. Swanson, 1940: 190). Experimental evidence suggests that buds and catkins are not stout enough fare for prairie chickens in winter (Hamerstrom *et al.*, 1941), while sharp-tails obviously thrive on them. Food may thus have been an important factor in the movements of both species, chickens moving in search of high-concentrates or less severe weather and sharp-tails moving to a different food source—browse—wherever it could be found.

On the other hand, brush may also be important to sharp-tails as winter cover, apart from the food relationship. The prairie chicken in the Lake

States also goes to the brush and open woods in autumn and winter more than in summer. But it feeds and roosts for the night, in winter, mainly in the open. Sharp-tails feed and roost to some extent in the open in winter, but they spend much more of their time in the thickets and woods than the chickens do. Some sharp-tails feed on cultivated grains in winter; those which do, seem to spend more of their non-feeding hours in the open than those without grain. The great bulk of the evidence, however, indicates that sharp-tails do not need grain. It is possible that sharp-tails require either grains as food or woody vegetation for shelter to get through the winter—that a highly concentrated diet may make up for a deficiency in cover. The possibility seems worth exploring.

Nor do we know exactly how the packs form. Sometimes packing seems to be no more than a local gathering of neighboring coveys. Of a half-dozen thickets bordering a meadow, for example, only one may have the kind of cover that will draw sharp-tails to it. Coveys may meet at this place from day to day, and finally coalesce. A grainfield might attract several coveys in much the same way. Sometimes, however—as we saw it near Bear Bluff, Wisconsin, in the autumn of 1936—it looks as though something more were involved. Unusual concentrations of this sort may possibly be a hold-over from the day when sharp-tails customarily gathered together in large flocks in preparation for a long journey in company.

These two movements—the seasonal shift and packing—are the key to a great deal that is still to be learned about sharp-tail ecology. Is there a mixing of stocks at the times of packing and dispersal? Band returns suggest that some mixing does occur, but we do not know when. Do the same birds return to the same openings to breed, or do they seek breeding places at random? The fact that dancing grounds are so often used year after year suggests that some cocks return to a familiar place. What about the hens? Do the birds go back to the places in which they wintered before, or do they go to any place that seems suitable? Band returns, among the birds which eat grains in winter, show that some use the same feeding places in later years. What about the birds which eat no grains, and are not caught in winter trapping? What is the history of the birds which appear in the grain stubbles in the autumn and later go away? The birds which come to grains in spring?

Perhaps these questions can be brought into better focus by recalling a few specific examples. At several places in Wisconsin sharp-tails were coming to grains in numbers in the autumn. In early winter there was a sharp falling-off in numbers, and for most of the rest of the winter very few birds were present. This happened near Bear Bluff in 1936, on the Solon Springs area in 1939, on the Moqua Barrens each winter from 1936 through 1938, and on parts of the Nicolet National Forest in 1939 and 1940. At some of these places, but not at all of them, more birds came to the feeding places toward spring than there had been in mid-winter, but there still were fewer than there had been in the fall. When these birds first appeared at the feeding stations, where and how far had they come from? When they left in early winter,

where and how far did they go? Why did they go? Food was still available. Some apparently remained nearby but some—perhaps the majority—did not. Did the same birds that had been there earlier come back to breed in these areas, or were the few which wintered in the neighborhood the only local breeders?

One thing more. Sharp-tails will tolerate more brush invasion into open cover than prairie chickens will, but they are not woodland birds to the extent that ruffed grouse (*Bonasa umbellus*) are. From the standpoint of ecological succession, sharp-tails are intermediate between these two. Especially in the eastern parts of their present range, sharp-tails are doubly vulnerable to changes in plant composition. Open herbaceous cover may be lost through cultivation and over-grazing. Most of their original range is now gone, lost in this way. Open cover may also be lost through brush invasion in the course of plant succession. Much of the acquired range in the "Cut-over" has been lost in that way. And winter cover may be lost through the further succession from thickets and open woods to forest. It might be assumed that if a group of sharp-tails lost one kind of habitat in one place it could find the same thing elsewhere, since they are accustomed to moving between types anyway. "Elsewhere," however, offers slim pickings. In the Lake States present habitat—especially open cover—is growing in at much faster rate than suitable new areas are appearing. The net result is a continuing loss of sharp-tail range. Less range means fewer birds.

Thus we come again to the necessity for sharp-tail management, if the steady decline of recent years is to be halted. Sharp-tail management is mainly land management—to make and hold the kinds of food and cover that sharp-tails must have in order to survive. Its problems are local, concrete, and immediate. A beginning has, in fact, been made. A great deal can be accomplished with the techniques that are already known. But without the answers to some of the questions above, the point of diminishing returns may be reached unduly soon.

SUMMARY

This paper is based on data from three sources: our own field work in Wisconsin (August 1935 through September 1937, and the autumns of 1938 and 1939) and in Michigan (the autumns of 1943, 1946, and 1947); retakes of 177 of 765 sharp-tails banded in Wisconsin mainly by Franklin J. W. Schmidt and the U. S. Forest Service; and an extensive survey of both published and original material covering movements within the geographic range of the species.

Our local studies in Wisconsin and Michigan have shown the following:

1. In late summer and early autumn, sharp-tails live mainly in open cover—grassy openings, or low or scattered brush. At about the time of the beginning of leaf-fall they begin to spend most of the day in thickets and open woods, and along the edges of such cover, although they still roost in the open

at night. On brisk, still, autumn mornings the males display on the same dancing grounds that are used in spring. Some segregation of the sexes results from this habit, at least during part of the day.

2. Autumn coveys vary in size from 8-10 to about 30. They have definite covey ranges, using the same thickets, woods, and edges day after day and roosting at night nearby. Daily cruising radius is ordinarily about a mile, sometimes less.

3. Later in the autumn sharp-tails group together into packs. Packs are apt to be larger where the birds are eating grains than in areas where they eat only natural foods. The details of pack formation are not clear.

4. In winter, sharp-tails live mainly in the edges (rather than the deep interiors) of brush and open woods. They spend part of their time in the open, especially those which feed on grains, but most of it in the woody cover. Daily cruising radius is usually about a mile.

5. In the Lake States, however, many of the birds disappear from grain stubbles and feeding stations about the time of the first snows. Sometimes a grainfield is wholly abandoned; sometimes part of the birds go while part stay through the winter. Often there is a return to these fields at the end of winter. We understand neither the cause nor the extent of these movements, which have occurred even where grain was kept available all winter long. In North and South Dakota, by contrast, sharp-tails commonly continue in the grainfields throughout the winter.

6. The packs disperse in spring and the birds return to open cover. We know very little about spring and summer movements, although the cocks probably stay close to their dancing grounds at least until June.

Banding has given the following information:

1. Autumn returns: 79 per cent of 94 complete returns were within three miles of the banding place, 69 per cent within two miles. The longest move was 21 miles.

2. Winter retakes: One lot of 657 birds was banded at 26 stations in five townships during three winters; 27 birds were retaken in winter. Twenty-one were retaken only at the place of banding, six of them during the winter in which they were banded, 10 the second winter, four during both the same and the second winters, and one during the same and third winters. Two were retaken in place during the second winter and at another place nearby during the third; four were retaken only after they had moved. The longest movement was between two and three miles. Another lot of 108 birds, in which the trapping stations were too far apart to give a fair test of movements, showed 48 birds re-trapped in place during the same winter, two during the same and second winters, and two during the second winter only.

3. Spring: Three males were re-trapped on dancing grounds during the second spring after banding; all were within a mile and a half of the winter

banding stations. Another male, re-trapped presumably on a dancing ground, was a half mile from the winter trapping station in the first spring after banding.

4. Altogether, 167 birds were retaken 242 times. Of 162 birds with complete data, about 38 per cent were retaken in place only, 81 per cent within two miles; only 12 per cent were more than three miles from the banding place, and 10 per cent more than five miles. The longest move was 21 miles.

5. Practically every bird was banded in winter. These retakes, which came during the same and later winters and at other seasons of the year, strongly suggest that many sharp-tails have an annual cruising radius of not more than a mile or two. A few birds, however, moved farther. The data are not extensive enough to show what *proportion* is sedentary and what *proportion* moves more widely. Especially little is known about the movement away from grains in mid-winter, about spring dispersal, and about movements in summer and early autumn. There are no banding data at all for those birds which live wholly apart from cultivated grains.

6. Ten returns from 48 transplanted wild-caught sharp-tails, not included in the above data, suggest that transplanted birds may wander more widely than those in familiar country.

Through a survey of the literature and correspondence with ornithologists in other parts of the sharp-tail's range, it is plain that:

1. The seasonal alternation between open and woody cover is characteristic of the three southern races. In some places sharp-tails use woody cover in summer more than they do in others, and in some places they stay more in open country in winter than they do elsewhere; nevertheless, alternation is the general rule.

2. When sharp-tails were abundant on their original range in the prairies and plains, the movement between cover types was often on a grand scale. In fact, this movement was often termed migration.

3. Sharp-tails are now essentially gone from the prairies and are much reduced in numbers on the plains. In most places the remaining range is in or close to brushlands, in rough haylands close to brushy ravines and draws, and in small openings in the "Cut-over." Thus, the seasonal movement is now on a much reduced scale.

4. Packing is associated with the shift to woody cover, and pack dissolution with the return to open cover.

5. At times of unusual abundance in the past, there have been, in Canada, sharp-tail emigrations. In a less conspicuous manner, but over a wider range, sharp-tails have temporarily expanded their range during cyclic highs. In either case, sharp-tails have lost their newly-won ground during the next cyclic decline. There have been, however, examples of successful range exten-

sion. All three of these movements—emigration, temporary range expansion, and range extension—seem to be strongly influenced by population density.

We conclude that:

1. Sharp-tails have been progressively losing range in the Lake States in recent years. Less range means fewer birds. If this loss is to be stemmed, sharp-tail management is necessary.

2. At present, sharp-tail management in the Lake States is largely a matter of brush control. Some of the techniques are already known.

3. Management must also take sharp-tail movements into account. A clearer understanding of the reasons for, and the details of, packing and the seasonal alternation between habitats is needed, if management is to be fully effective.

APPENDIX

A SURVEY OF SHARP-TAIL MOVEMENTS, FROM BOTH PUBLISHED AND ORIGINAL SOURCES

The bold-face symbols serve as a finding index, showing both the kind of movement and the date of publication or the date of the observation. The date thus does not always agree precisely with the time of observation, but it does in most cases give a good approximation of it.

Explanation of symbols: C—Movement to woody cover for the winter; E—Emigration; M—Migration; Q—Quasi-migration ("partly migratory," etc.); R—Resident; V—Seasonal visitor; ? (after one of the above)—An interpretation, ours or the author's, of data which are not wholly clear; *—See text for the supporting quotation.

1 We know of no specimens to support this statement.

2 Stockwell also mentions *columbianus* as "extremely rare" in the Lower Peninsula. This does not, however, imply long movement because Lake States sharp-tails were known as *columbianus* in 1877.

3 We question this use of the term "migration" for local movements of only a few miles.

4 Josselyn Van Tyne and we have examined eight specimens (6♂♂ 2♀♀) which Williams identified as examples of North Dakota *columbianus*. These skins are in the University of Michigan Museum of Zoology and Max Minor Peet collections. None of them seems to us referable to *columbianus*, and none differs significantly from typical *jamesi* of the region.

5 The Holden reference may apply to both Wyoming and Colorado.

6 Like Snyder (1935a), we think that the mass movements of 1896 and 1932 should be called emigrations rather than migrations.

1. United States (See also Part III). MICHIGAN: E?—Stockwell 1877: 241—*phasianellus*: "An occasional visitor to Lower Michigan . . ." ^{1,2} R—Wood 1905: 177—" . . . at Siskowit Bay throughout the year." R, M³—Peet 1909: 340, 348—"Permanent Resident . . . During the fall they make local migrations. . ." R, V—Barrows 1912: 234, 235—Isle Royale: "resident." " . .

long ago . . . a winter visitor, in parts of the Upper Peninsula¹¹ in the opinion of A. B. Covert and Morris Gibbs. R—Van Tyne 1938: 11—"Permanent resident. . . ." R, M?, C*—Baumgartner 1939: 486, 488—" . . . flocks of resident birds tend to stay in the vicinity of dancing hills. . . Others, perhaps winter migrants, wander over considerable areas."

WISCONSIN: R—King 1883: 591—" . . . resident from Berlin northward . . ." C—Cooke 1888: 106—" . . . quite abundant on Sisson's prairie . . . in the fall of the year, but as soon as cold weather sets in they keep in the edge of the woods." R—Schoenebeck 1902: 22—*campestris*: "Resident; common." *columbianus*: "Visitant; rare. On Oct. 25, 1897, I shot an old male. . ." [Specimen lost; record considered "erroneous" by Hollister (1912).] R—Kumlein and Hollister 1903: 57—"Resident." M?—Leopold 1931: 174—"Winter migrations were possibly not confined to pinnated [grouse]"; in Rock county, in the 1850's " . . . great flights of grouse (sharptails) arrived late in fall when the snow came. . . In the spring they went back" (quoting Orrin Sutherland). [However, Schorger (1944: 28) thinks "there is doubt that the flights consisted of sharp-tailed grouse."] R—Leopold 1933: 76—Cruising radius: Daily—average, 1/2 mile; maximum, 2 miles. Annual—average, 1 mile; maximum, 3 miles (citing Schmidt, unpubl.) Q, M, E?—Schorger 1944: 27, 28-29—" . . . has been considered to be more or less migratory in autumn." A "migration" in the autumn of 1865, and perhaps also in 1874 and 1883. [Might these not have been emigrations? Schorger refers to the emigration of 1932⁶ in Ontario as "migration."] M⁶ E?—Scott 1947a: 27—"In earlier days . . . migrations have been known to take place." Examples: 1932⁶, 1865 (citing Schorger, above).

ILLINOIS: R?—Ridgway 1873: 382—"Resident? Northern prairies only." R—Ridgway 1881: 191—"Resident; northern prairies only."

MINNESOTA: R, C—Roberts 1932: 395, 397—"A permanent resident"; formerly "retreated to the timber to pass the winter. The flocks do not go south as do those of the Prairie Chicken." V*—Johnson 1934: 8—observations in 1889-1902. C—Krefting 1941: 26—"Formerly abundant on prairies in summer and 'retreated north to the timbered sections' during winter. R—Schrader and Erickson 1944: 15—" . . . unlike the pinnate it does not migrate south in winter."

IOWA: R—Cooke 1888: 107—" . . . rare residents at Grinnell, Iowa." R?—Spurrell 1917: 156-7—"Although Spurrell described prairie chicken migrations in detail, he did not mention migration in his discussion of the sharp-tail (1850's). M—DuMont 1934: 57—"A rare winter migrant" in northwest Iowa. M—DuMont, letter, 1948—"Actual winter migration of this bird in Iowa is extremely sporadic" (P. A. DuMont, U. S. Fish and Wildlife Service, Washington, D. C.).

NORTH DAKOTA: C—von Wied 1858: 437-438—"On the open prairies in spring, but: 'Im Herbst halten sich gewöhnlich ein Paar Gehecke bei einander, und ihre Flüge sind dann zahlreich, sie suchen alsdann auch schon mehr die Nahrung in den Gebüschchen. Im Winter geben ihnen die Gebüschchen Schutz vor der rauhen Witterung. . . ." V—E. T. Judd 1893: 382—"The fall of 1891 there was an unusually large flight of sharp-tail grouse that struck this county in the early part of November. . . ." M*—E. T. Judd 1917: 15. V—Freeman 1919: 12—"Winter visitant. Uncommon." M, C—Wood 1923: 36—"In winter this species migrates southward and enters all the timber tracts in numbers." Cites Williams on *columbianus* (see next entry). R, V—Williams 1926: 30—[*jamesi*] "A common resident" about 15 miles away; locally "it is seen only during winter months." *columbianus*: "A rare winter visitor in this immediate

vicinity, but is quite common during winter in the Pembina Mountain region." **R**—Larson 1928: 46—"A common resident, which nests abundantly." **R**—Aldous 1943: 25, 31—Banding shows no evidence that sharp-tails "migrate south or that one sex migrates." "Their daily and seasonal movements, are usually for short distances." **C**—Bach, letter, 1948—"I agree with you that the general movement of prairie to brush and return is the basis for Sharp-tail movement. Sometimes that may have taken quite a distance; sometimes not so far." Roy N. Bach, North Dakota Game and Fish Dept., Bismarck)

SOUTH DAKOTA: **R**—McChesney 1877: 224—"Resides here throughout the entire year. Is at no time numerous." **R**—McChesney 1879a: 85—"... in small numbers throughout the entire year." **R**?, **V**—Agersborg 1885: 285—"Winter visitor. Occasionally seen during summer. Breeds." **R**—Reagan 1908: 464—"A very common resident." **R**—Visser 1909: 147—"Abundant resident on plains." **R**—Visser 1911: 10—"Very abundant resident along the permanent streams and in the park-like area at the top of the buttes and near their base." **R**—Visser 1913: 567—"This grouse replaces the Prairie Chicken [listed as an "abundant resident"] in the wide, sandy stretch southwest of Forestburg." **R**, **M**—Over and Thoms 1920: 77—"Late in the fall several coveys may flock together and migrate a short distance, perhaps for more favorable feeding grounds. It should, however, be classed as one of our resident birds." **R***, **C***—Reuel Janson (South Dakota Dept. of Game, Fish, and Parks, Mobridge) letter, 1948.

NEBRASKA: **V**—Hall 1883: 284—"This species is no longer a resident of Northeastern Nebraska, where it once used to breed. A few winter, . . . breeding in North Nebraska and Dakota." **R**—Bruner 1896: 82—"Resident, formerly abundant, becoming rare" (Taylor)." **R**—Swenk 1902: 54—"Common resident in western Nebraska, uncommon eastward." **R**, **V**—Bruner *et al.* 1903: 46—"A common bird in the sand-hill region . . . where it breeds; formerly spreading to the eastward in winter to Cuming and Dodge counties." **C**?—Viehmeier 1941: 3—"The prairie . . . furnished nesting sites and food. . . The woodlands along streams and canyons furnished winter cover and an additional food supply." **R**—Mohler 1944: 6—"Prairie chickens move out of the sandhills in winter, but: "Observations of sharp-tails more than a few miles south or east of the sandhills are relatively rare." **R**—Haecker *et al.* 1945: 11—"An uncommon permanent resident in the sandhills region and in northwestern Nebraska." **R**—Tout 1947: 37—"This Grouse is a permanent resident in Lincoln county, formerly very common, recently quite rare but said to be increasing. . . ." **R**, **C**—Mohler, letter, 1948—"I believe that there is no mass movement or long distance movement of Nebraska sharp-tails. . . Much of our breeding range is grassland with some very low-growing brush which does not afford a particularly attractive winter condition. Sharp-tails do, of course, shift locally to the brushy or wooded parts of [their] habitat such as that along streams and in the vicinity of lakes and marshes in the sand-hills region." (Levi L. Mohler, Nebraska Game, Forestation & Parks Commission, Lincoln).

KANSAS: **R**—Goss 1886: 20—"Resident in middle and western Kansas; becoming rare." **R**, **C**—Goss 1891: 228, 229—"A common resident in the western part of the State . . . inhabits the open prairies during the summer months, retiring in winter to the ravines and wooded lands. . ." **R**—Lantz 1899: 254—"Resident in the western part of the state; common." **R**—Snow 1903: 15—"A common resident in western Kansas." **R**—Long 1940: 440—"Formerly a common resident; now probably extinct in the state."

OKLAHOMA: **R**—Nice and Nice 1924: 37—"A former resident in the Panhandle, nearly extirpated." **R**—Nice 1931: 81—"Former resident in northwestern Oklahoma"; no record since 1920.

MONTANA: R—McChesney 1879b: 2392—"Is resident and common in the region visited." R, C—Silloway 1903: 24—"A very common resident of the prairie regions and the foot-hills. . . During the coldest weather of winter these grouse congregate in large flocks, resorting to the timber in the creek bottoms and coulees." R—Saunders 1911: 35—"Resident in the valleys." R—Saunders 1912: 25—"Resident of the Jefferson and Deer Lodge valleys." R, C—Saunders 1914: 131—"Permanent resident of the prairies. . . In winter the birds gather in large flocks in the thickets. . ." R, C?—Saunders, 1921: 58, 59—*columbianus*: "A fairly common permanent resident of the mountain valleys" in western Montana. "It is confined to open grass lands and grain fields . . . though occasionally found among cottonwoods and willows or pine hills in winter." [jamesi]: "A permanent resident of the prairies and plains" in eastern Montana.

WYOMING: V⁵—Holden 1872: 208—"None were seen in summer. A few seem to pass the winter here." R—Knight 1902: 56—"Resident. . ." (Two races.) R—Grave and Walker 1916: 40—[jamesi] "Resident and common. . ." (quoting Knight). *columbianus*: "resident" in three local lists. R—McCreary and Mickey 1935: 129—"Permanent residents" (Two races.) R—McCreary 1939: 28—Both races "resident."

COLORADO:⁵ R—Morrison 1888: 182—"Resident. . ." (Two races.) R, M³—Cooke 1897: 71—" . . . strictly resident. When they were more abundant they used to perform a short migration in eastern Larimer County, moving into the foothills in the summer and coming down onto the plains in immense flocks in the fall." V—Cooke 1900: 203—"Mr. Carter says that they breed in Middle Park . . . not above 7,500 feet. In winter they have been noted up to 9,500 feet." R, V—Keyser 1902: 320—"Resident, not common. . . ; some breed in Middle Park; noted in winter at 9,500 feet." R—Gilman 1907: 153—"A few scattered on the mesas at about 7,500 feet. Resident thruout [sic] the year." R—Rockwell 1908: 161—" . . . strictly resident wherever found." V—Warren 1909: 14—"Some seen every winter; they breed at higher elevations (Smith)." V—Cary 1909: 181—"On the slopes of Lone Cone the breeding range is in the partially open oak and aspen country between 8000 and 9500 feet. According to Mr. C. H. Smith of Coventry, it is only during the severest winter months that Sharp-tailed Grouse occur as low as 6500 feet." C—Sclater 1912: 153—"It is a bird of the prairie [eastern Colorado] in summer, retiring in winter to ravines and wooded lands. . ." R—Niedrach and Rockwell 1939: 62—"Resident; not common."

NEW MEXICO: Q, M—Ligon 1946: 48—Formerly migrated; " . . . to a certain extent, the ancestral urge survives."

IDAHO: C—Merrill 1897: 352—"Quite common . . . about ranches on the extensive prairie north of the fort. In the winter it penetrates into the pine woods for considerable distances. . ." R—Rust 1915: 123—"Becoming rare as a resident. . ."

UTAH: R—Henshaw 1874a: 10—"Resident." (See also Henshaw (874b: 50) R, M³—Lee 1936 (MS)—" . . . remains in the same general area throughout the year" but may make "slight migrations of one to two miles in the winter in search for berries." R, C*—Marshall and Jensen 1937: 98—"The daily cruising radius is probably a half mile and the annual about two miles. . ." R—Behle 1944: 72—"Resident locally in northern Utah in small numbers where the original grassland remains." V?, M?—Low and Gaufin 1946: 180—"Speculation arises as to whether these birds were migrating from an area of too great concentration . . . or whether the flight was part of a regular spring movement which we have not detected before."

WASHINGTON: R—Johnson 1906: 26—Listed among the "Permanent Residents." Q, C*—Dawson and Bowles 1909: 598—"In the early days it was partially migratory. . ." R—Dice 1916: 301-310—"Resident" in sagebrush, bunchgrass (the major habitat) and cottonwood-willow habitats. C?—Dice 1918: 44—"They sometimes feed on the buds of the trees along the stream in winter, but are very seldom seen near timber in the summer." (And see also text). C?—Wing 1944: 5—"The birds are said to winter in the cottonwood trees along the moist draws opening into the flat" near Omak.

OREGON: R, C?—Bendire 1877: 139—"Only a moderately common resident . . . mostly found in the juniper groves during the cold weather. . ." R—Woodcock 1902: 27—"Haines. . . Resident; common; breeds." R—Gabrielson and Jewett 1940: 216—" . . . an uncommon resident of a few counties."

CALIFORNIA: R, V?—Cooper 1870: 533—" . . . resident species throughout all its range, or only descends from the high lands to the warmer valleys in the cold months." R—J. Grinnell 1902: 30—"Fairly common resident in the northeastern corner of the State. . ." Q, C*—Dawson 1923: 1601—See Dawson and Bowles, above (Washington). R—Grinnell and Miller 1944: 116—"Resident and formerly abundant (up to about 1880) on suitable parts of northeastern plateau region. Persisted, in lessening numbers, up to about 1915. . ."

II. Canada and Alaska (See also Part III). HUDSON'S BAY REGION: R—Forster 1772: 396—" . . . they are found all the year long, amongst the small juniper bushes. . ." R—Hutchins 1782 (MS)—"These birds keep in pairs or small flocks and frequent the Juniper plains all the year. . . They generally inhabit about the same spot, unless disturbed. . ." ("Observations on Hudson Bay," quoted in Seton, 1891: 516). R—Pennant 1785: 307—"It continues there the whole year; lives among the small larch bushes, and feeds, during winter, on the buds of that plant and the birch. . ." R, V?—Hearne 1795: 408—"Those birds are always found in the Southern parts of the Bay . . . and in some Winters a few of them are shot at York Fort. . ." R, V—Nuttall 1832: 669—" . . . found around Hudson's Bay in the larch thickets throughout the whole year." In spring "it also visits the vicinity of Fort William. . ." V—Fleming 1906: 19—"According to Bishop Newnham the Sharp-tails arrive at Moose Factory, James Bay, from the north-east, usually when the marsh hay is being gathered. . . They frequently stay all winter and leave in the spring."

QUEBEC: (See also: Bent (Alaska): E?—Dionne 1883: 160—"Cette Perdrix . . . se rencontre dans Ontario à de rares intervalles; elle visite même notre province. . ." M⁶, E⁶—Déry 1933: 3, 4—" . . . a preliminary report of the abnormal migration in progress. . . This Grouse from Hudson's Bay has, since the 15th of October 1932, reappeared, after an absence of thirty eight years. . ."

ONTARIO: (See also: Nuttall (Hudson's Bay), Dionne (Quebec), and Bent (Alaska): M⁶, E⁶—Fleming 1901: 37—*phasianellus*: "In October of 1896 a southern migration of this Grouse took place." R—Nash 1905: 35—"A scarce resident of the north-western part of the Province." V, E—Fleming 1906: 19—"On Lake Timiskaming they do not seem to occur regularly, though the bird is frequently found there in October. . . In 1896 a flight passed south of the usual limits into the districts of Parry Sound and Muskoka. . ." V, E*, C*—Snyder 1935a: 14—Lake Abitibi: " . . . residents informed the writer that these grouse occur in the fall and winter, not in summer. At Lake Nipigon a similar condition prevails. . ." (See also Part III) R—Baillie and Harrington 1937: 29—" . . . a more or less common summer resident of extreme northern and extreme western Ontario." E—MacLulich 1938: 12—" . . . this species undoubtedly invaded the park on its southward emigrations in 1896 and 1932."

M⁶, E⁶—Ricker and Clarke 1939: 8—"North Bay was, except for scattered records, the southern limit of the great migration of these birds in the fall of 1932." E—Baillie 1947: 50—*phasianellus*: "During some winters, these grouse emigrate southward. . ."

MANITOBA: (See also: Raine (Saskatchewan): R, Q, C—Seton 1886: 153—"Very abundant resident" in southern Manitoba. "This species lives exclusively on the open prairie in the summer, and exclusively in the wooded districts in the winter, so that it is in a sense migratory." R—Cooke 1885: 34—" . . . resident and common at Portage la Prairie. . ." R, Q, C—Seton 1891: 516—"Carberry: Abundant; resident; partly migratory, as it lives on the prairies in summer and in the woods in winter." "Resident in the Northeast." C—Macoun and Macoun 1909: 232—"At the approach of winter a large percentage of these birds retire to the more wooded country and to the low sandhills near Aweme, Man. (Criddle.)" E—Shortt and Waller 1937: 18—"Particularly abundant in 1932, when *phasianellus* "was making one of its periodic southern invasions." R?—Malaher, letter, 1948—"No known modern counterpart of the seasonal movement described by Seton; see text. (G. W. Malaher, Director of Game and Fisheries, Man. Dept. Mines and Nat. Res., Winnipeg) C—Hochbaum, verbally, 1948—"Sharp-tails habitually move to the timbered and brushy ridge at Delta for the winter; they are not found there in summer. (H. A. Hochbaum, Delta Waterfowl Research Station, Delta, Man.)

SASKATCHEWAN: R, C—Raine 1892: 31—"The species is resident in Assiniboia and Manitoba throughout the winter, when they retire to the bluffs and feed on the buds of the trees. . ." R—Mitchell 1924: 108—"Usually common resident all through transition zone. . ."

ALBERTA: R—Soper 1918: 132—[jamesi]: "Common permanent resident." C—Soper 1921: 52—[jamesi]: In late August and September "they were commonly found on the open prairie or grain fields. After the snow fall of October 7 and 8 . . . the birds took up their winter quarters in good thick bluffs. . ." M?, E?—Rowan 1926: 336—"In years such as the present, following on a cyclic peak and preceding a minimum . . . our Grouse apparently undertake considerable migratory movements. . ." [But see letter, below] E*—Rowan 1948: 5, 7. An instance in 1942 is described; discussion of others. R, E—Rowan, letter, 1948—"When abundant they undoubtedly undertake extensive movements . . . not . . . true migration, for I have little doubt that they never return from the point at which they started. When they are scarce they are virtually resident." (William Rowan, University of Alberta, Edmonton).

BRITISH COLUMBIA: R—Fannin 1891: 21—"An abundant resident east of the Cascades." R—Munro 1917: 84—[columbianus]: "Resident. Grouse of all species have become very scarce during the past two years." R—Brooks and Swarth 1925: 52—[columbianus]: "Resident, common locally, in the lowlands of the interior." R—Munro and Cowan 1947: 94—"Resident in grasslands and parklands" (Three races). R, C—Munro, letter, 1948—"Here, when sharp-tailed grouse were plentiful (1911-1915), sporadic autumn movements took place, but I certainly would not consider these migratory . . . the topography of mountainous country is such that at no place are winter and summer habitats far apart. Grasslands usually are surrounded by brushy coverts, or forest, so that a few minutes flight would carry a covey from one to the other." (J. A. Munro, Dominion Wildlife Service, Okanagan Landing, B. C.)

ATHABASCA-MACKENZIE: M—Russell 1898: 261—" . . . rather common at Rae during the autumnal migration." Q, M—Preble 1908: 348-349—" . . . to some extent is migratory. . . It was abundant and apparently migrating at Fort Norman October 1. . ." At Fort Simpson in April "they again had become rare in the vicinity, probably having moved northward. . ."

ALASKA: V—Bent 1932: 287—"The species occurs only as a summer straggler in western Alaska . . . and as a winter straggler in southeastern Ontario . . . and Quebec. It has, however, occurred in summer at Fort George, Quebec." (But see also Bent (1932) and Ridgway and Friedmann (1946) in Part III, and Dice (1920) in text.)

III. MATERIAL COVERING SEVERAL STATES OR PROVINCES: R—Swainson and Richardson 1831: xxviii—"Across the continent [north of the 48th parallel] . . . resid." Q, C*—Bendire 1892: 97-102—"Northern races": ". . . more or less migratory. . ." *columbianus*: ". . . partially migratory. . ." [*campestris* + *jamesi*]: quotes Grinnell, below. Q, C—Elliot 1897: 127-132—*columbianus*: "In winter they frequently retire to the timbered country, probably as a refuge from severe storms and deep snows. . . I think, however, this is a common habit of all Sharp-tailed Grouse if they happen to be in a country where trees abound. . ." [*campestris* + *jamesi*]: ". . . partly migratory . . . being a good deal of a prairie dweller in the summer, but more of a woodland bird in the winter." Q, C?—S. Judd 1905: 21—"The sharp-tailed grouse are partly migratory. In winter they take refuge in the highest trees. . ." Q*, C*—G. B. Grinnell 1910: 256. R—Sclater 1912: 152—[*campestris* + *jamesi*]: ". . . probably a resident throughout. . ." R, Q, C—Laing 1913: 240—Northwestern States and western Provinces: ". . . none are really migratory . . . they spend the year around pretty much on the same grounds. True . . . the sharp-tail is also slightly migratory, in so far as he usually leaves his more open summer haunts to seek the shelter of the nearest scrubby woods, but as a rule he does not move any great distance." M—Bent 1932: 287—[Northern races]: "In common with some of the ptarmigans, there appears to be a definite migration from the northern part of the range, governed by the severity of winter conditions and the available food supply. This exodus, however, does not extend south of the breeding range." E*, C*—Snyder 1935a: 13-15. R—Ridgway and Friedmann 1946: 192-203—*caurus*, *phasianellus*, *jamesi*, *columbianus*, and *campestris*: "resident."

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Unusual Nesting Behavior of a Chimney Swift

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Two immature chimney swifts (*Chaetura pelagica*) were trapped and banded from air shaft D4 on the roof of Kent Hall at Kent State University on July 27, 1944. (For procedure see Dexter, 1950a). They had roosted there during the preceding evening with three previously-banded swifts, a breeding bird of the season and two other juveniles. The two new birds were marked with nos. 42-196952 and 42-196953. Later, the former proved to be a male which we shall refer to as no. 52, and the latter a female which we shall call no. 53. These two soon separated, but were to play an interesting role of animal behavior at a later date. Three days after banding the male again roosted in D4 with six other swifts, three of them residents of D4 during the nesting season which had just ended, and two of them birds of the year. One was not captured. (This might have been no. 53.) In any case, on September 25 no. 53 was recaptured in a flock of 44 chimney swifts from the near-by roof of Merrill Hall, and she was not with the male at that time. However, the two returned together the following year on May 19, 1945, when they were found roosting in shaft C3 with 86 other birds just back from the wintering grounds in South America. On June 7, nos. 52 and 53 spent the night in shaft L3 with an unbanded swift. From one to three birds had roosted there from time to time during the preceding two weeks and during the past week nearly all of the birds in the 13 other occupied air shafts were engaged in nest building; a few had already started to lay eggs. Nos. 52 and 53 were subsequently trapped at various intervals, and since these were the only two birds not already settled for the nesting season, it can be assumed that the two birds observed in the unusual behavior described below were the same two, and indeed occasional retrapping did prove that they were.

On June 17 the pair was observed roosting side by side in L1; the next night one bird was clinging to the wall directly below the other in this same shaft from which they were trapped; the following night they were nearly side by side again, still in L1, but as yet they had made no attempt to build a nest. On June 20, one bird roosted in L1 while the other roosted in the adjoining shaft L2. Two nights later they were both together back again in L1 and again sitting side by side. However, the next night one was alone in H4 while the other could not be located. On June 26 one was back in L1, and the other had moved into H1 with a pair of nesting birds and two all-season visitors which lived with the breeding birds. Two nights later both were again in L1 but roosted on different walls. This pair left once more in two days' time, but after three days returned to L1, although they remained six inches apart, while clinging to the wall. Neither was present the next night, but on July 3, they were side by side in shaft L1. Two nights later one was alone there, but both were present side by side the following night, only

to be absent the next night. On July 9, nos. 52 and 53 were recaptured from L1 where they had roosted side by side the previous night. Still no attempt had been made to build a nest although other swifts had done so a month ago. For the next 10 days these birds were not located. No. 53, the female, was then retrapped from H1 with the four birds residing there, two of which had nestlings at that time. The next day no. 52, the male, was retrapped from N9 with a pair of birds which had recently lost its four nestlings when the nest was washed off the wall during a heavy rainstorm. This was the last that swifts were seen in N9 and the last record of No. 52 for the season. On October 3, no. 53 was back again in H1, but this time she roosted alone. The next night, however, she roosted there with four other birds, two of which had resided there and may have been the mating birds of that shaft. This was the last ever seen of no. 53. During the next five years no. 52 was to be more successful in mating and nesting, with a life history similar to other birds in the colony (Dexter 1950b, 1951), but with variations of its own. His more nearly normal breeding behavior is described below.

The male returned May 8, 1946, when he was found in shaft A-1 with two other birds, one of which had nested there the previous year and continued to do so for the next three years. Five days later no. 52 was found alone in L1. On May 30, he was in L3 side by side with female 42-184484, but they did not remain there. On June 4, they were found together in K4; two nights later they were together in K2. Unfortunately the writer was absent for the balance of the nesting season, but upon his return a nest was discovered in shaft M1. Only once before, in 1944, and never since has nesting taken place in that shaft. It is possible, although there is no direct evidence, that no. 52 nested there with no. 84, since this pair was the only one not settled in the nesting process by the time the writer had to discontinue observations, and both returned to this shaft the following season.

No. 52 returned to M1 on April 28, 1947. At that time he was alone. Five days later two birds were observed there, and appeared to be in copulation; two days later no. 84 was retrapped there alone; but the next night two birds were together again (possibly 52 and 84). An unseasonal cold spell and late snow storm then drove all the swifts away from the roof for a period of four days. When the birds returned, no. 84 remained alone in M1 for over two weeks, eventually leaving to nest in N9 with the male that had nested there for the three preceding years. No. 52 moved into K7 and mated with the female, 42-196914, which had already nested there for the three previous years, even though her mate of the past three years had returned to her again. He soon disappeared when replaced by no. 52. The life history of no. 14 including its tragic mating with no. 52 in K7 is described elsewhere (Dexter 1951).

On April 25, 1948, no. 52 returned to K7 with its presumed mate of 1946 (42-194484), but they did not remain there. A week later they were together in shaft M7. No. 84 then went back to her mate of the previous year, and they nested again in N9. No. 52 joined the female in H5 where she had nested for the past four years with three different mates during that

time. The new pair completed a nest the last day of May, placed 12 feet down on the north wall. Four eggs were laid, but one was lost. In 1949 no. 52 nested there again with a new female, the former mate not returning to the campus that year. The new nest, however, was placed over three times as far down, 38 feet from the top, on the north wall. In 1950 no. 52 returned to H5 on May 11 with another new bird. Three days later, however, he went back to K7 with his mate of 1947, but they failed to nest there a second time. No. 52 once more took up residence in H5 with still another new female (48-164550), where they nested beginning on June 26, about one month after most of the other birds began their nest building. This time the nest was fastened on the south wall, but still 38 feet down the shaft. Three nestlings were raised. The mates remained to roost nightly in H5, after the nestlings left in middle August, for nearly a month.

SUMMARY

During six years of observations on a male chimney swift, a member of a breeding colony on the campus of Kent State University, Kent, Ohio, it was determined that this particular individual (42-196952) was incompatible with his first selected mate, had a different mate for five successive nesting seasons in three different air shafts, but succeeded in completing reproduction four times.

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A Survey of the Helminths and Ectoparasites of Roof and Cotton Rats in Brazos County, Texas*

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INTRODUCTION

This investigation deals with the examination of 102 roof rats, *Rattus rattus frugivorus* Rafinesque, and 30 cotton rats, *Sigmodon hispidus hispidus* Say and Ord, for their internal and external parasites. All were trapped in or near College Station, Brazos County, in east-central Texas, February, 1948, to March, 1949.

Rattus rattus frugivorus appears to be the only domestic rat present in the Brazos County area. *Sigmodon hispidus hispidus* is the common wild rat of fields and vacant lots. Thus, a comparative study is made of the parasite burdens of representatives from two families: the imported, or Old World, roof rat (Family Muridae), and the indigenous, or New World, cotton rat (Family Cricetidae).

Since the turn of the century many reports on the parasites of domestic rats have appeared, but little has been published on the parasites of cotton rats until quite recently. Harkema and Kartman (1948) reported their examinations of cotton rats for helminths and ectoparasites in Georgia and North Carolina, stating no previous helminthic survey had been published. However, Baylis (1945) had listed the helminths found in cotton rats sent him from Southern States. Chandler (1922) earlier had found a new cestode, *Schizotaenia sigmodontis*, in about 75% of 96 cotton rats from East Texas. Again, in 1932, he described a new nematode, *Longistriata adunca*, occurring in cotton rats in the vicinity of Houston, Texas. In recent years much work has been done with the filarial worm, *Litomosoides carinii*, by Scott and Cross (1946), Bertram (1946), and Williams (1948).

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METHODS

A successful method of obtaining roof rats alive so that ectoparasites would remain on their bodies was by the use of small "O" gauge steel

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traps, not baited but set in runways. Rats were caught by their legs as they ran over the traps, especially on rafters and beams selected for tell-tale dark smudges. Cotton rats were caught by placing small Sherman live traps in their tunnel-like runways in the tall grass of vacant lots, fields, or roadsides. They lack the caution and cunning of roof rats and are easily enticed into the traps with oatmeal.

Before removing a rat from a trap, it was stunned and dropped into a small cotton sack to retain the ectoparasites. The rats were then killed and combed for ectoparasites and autopsied for internal parasites. Cestodes were fixed in Gilson's fluid and stained for the most part with Harris haematoxylin, although Delafield's haematoxylin and alum cochineal were also used. Nematodes were dropped into hot 10% formalin and cleared in lacto-phenol. Anterior ends were severed and mounted lips up in glycerine jelly. Diseased organs were embedded in tissue-mat, and serial sections were made.

RESULTS

RATTUS RATTUS FRUGIVORUS

A total of 102 roof rats were examined from 16 different locations, all but two of which were barns. Thirty-seven of the rats were males, and forty-eight were females; the sex of 17 rats was not recorded. In 16 pregnancies observed, the average number of embryos or fetuses was 7.5, the number ranging from 2 to 11 per rat. The average overall length of the rats was 31.8 cm., the two largest being 43 cm. each. Davis gives the overall length of *R. rattus* as 37 cm., which indicates that in the present survey many young rats were caught.

Consultation of tables 1 and 2 reveals that the tropical rat mite, *Liponyssus bacoti* (Hirst, 1913), was the most abundant parasite, both as to the number of hosts infested (61) and as to the total number of parasites collected (2,577, with an average of 47.9 mites per rat). Next in prevalence was the rat louse, *Polyplax spinulosa* (Burmeister, 1839), which occurred on 49 of the rats. Very few fleas were found. It must be kept in mind, while reading the tables for ectoparasites, that some rats were dead when found. Also, it is to be expected that some ectoparasites were shaken off by the struggling of the rats in the traps. It was noted that many rats on which no lice could be found had nits on the hairs.

Too few rats were caught each month to arrive at any sound conclusion concerning seasonal variations of parasites, but Table 1 shows that the incidence of ectoparasites was lower in the fall than in the other seasons. This is correlated with information on the host-record sheets which shows that not only were fewer rats infested in the fall, but also fewer ectoparasites per infested rat were removed during that season. It may be significant that the first rat taken alive which had no ectoparasites was caught on October 10; it was the 76th rat examined. It may be of significance also that the largest number of ectoparasites removed from a single individual was taken from a young rat caught on April 28; 250 mites were counted before the tabulation was discontinued. A similar seasonal variation of lice and mites was observed by Schoof (1948) in a recent survey of 854 rats in North Carolina.

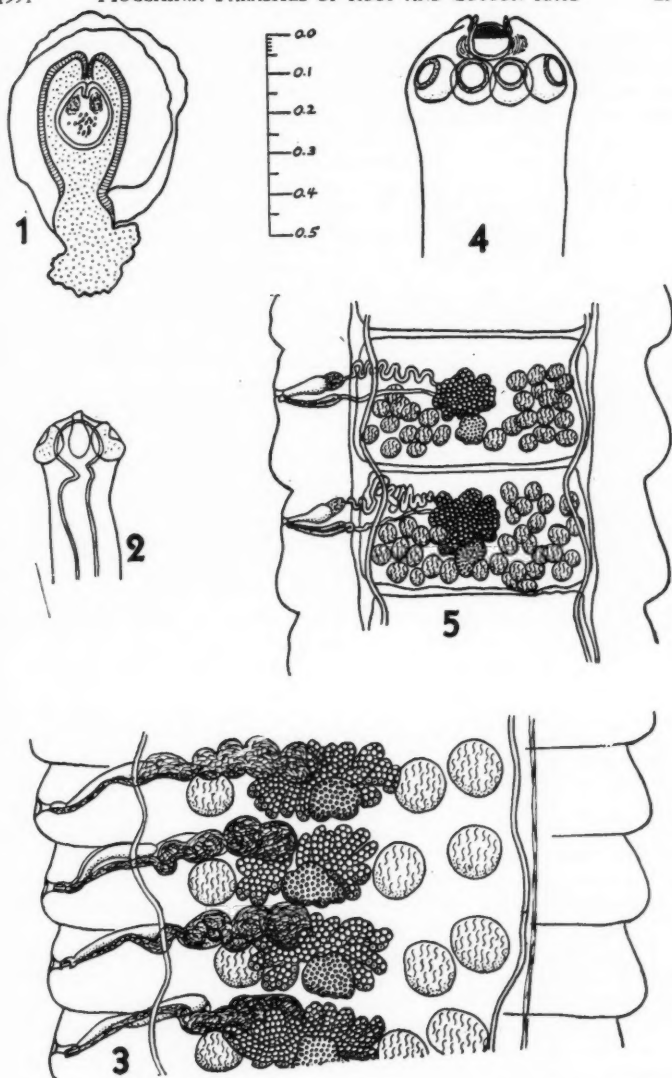
In the present investigation, rats from the same location usually harbored the same ectoparasites, but one interesting exception was observed. Of two rats caught in the same feed room on the same night, one rat harbored 38 mites, more than 100 lice, and no fleas, while the other rat harbored 5 fleas but no mites nor lice. The first rat was interesting for another reason, also; mites and lice usually did not occur together on the same host in such large numbers.

The most common internal parasite, as can be seen in the tables, was the oxyurid nematode of the caecum, *Syphacia obvelata* (Rudolphi, 1802). In many cases, the caecal contents were teeming with the worms. The only other helminth found in numbers was the common rat tapeworm, *Hymenolepis diminuta* (Rudolphi, 1819). The tapeworms showed much variation in size, a few unusually large specimens being recovered. Belding (1942) states that the maximum width of the strobilus of *H. diminuta* is 4 mm.; the largest specimen found in this survey reached a width of 6 mm., but this unusual width may have been due to contraction of the strobilus. The host of this overgrown worm was a large rat (39 cm. long) which carried 9 foetuses near term. It is interesting to conjecture as to whether hormones and other factors associated with the pregnant condition of the host had any bearing on the excessive size of the cestode. Addis (1946) has worked on the relation between sex hormones and the growth of *H. diminuta* in laboratory rats. He and Chandler (1946) have also worked on the vitamin requirements of *H. diminuta*, which play a part in growth. In this connection, another very interesting observation was made which might possibly have some relation to hormones or vitamins. Many mature proglottids of *H. diminuta* contained four testes instead of the normal number of three. The writer has seen no previous record of such a phenomenon.

TABLE 1.—Monthly incidence of parasites of *Rattus r. frugivorus*

No. of rats:	Feb.	Mar.	Apr.	May	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Caught	4	3	14	6	15	16	16	10	4	1	11	2	102
With lice	4	3	13	2	2	5	4	7	1	1	6	1	49
With mites	0	3	12	6	13	5	12	4	1	1	4	0	61
With fleas	0	2	4	0	0	1	1	0	0	0	0	0	8
With cestodes ..	1	1	5	3	4	7	4*	2	2	0	2	0	31
With nematodes in stomach	0	0	0	0	0	2	0	0	0	0	1	1	4
With nematodes in caecum	1	2	2	2	11	3	11	5	1	0	6	1	45
With dis- eased organs ..	0	0	0	0	1	10	0	0	0	0	0	0	11
With no internal parasites found	3	1	7	1	2	8	2	4	2	1	3	0	34

* One with cysticercus in liver.



Figs. 1-3.—*Hymenolepis diminuta*. 1. Cysticercoid from tenebrionid beetle; 2. Scolex; 3. Mature proglottids. Figs. 4-5.—*Raillietina bakeri*. 4. Scolex showing hooks on the rostellum and minute hooklets on the suckers; 5. Mature proglottids. All drawings were made with the aid of a camera lucida.

Although this investigation did not include examinations for protozoa, an interesting sarcosporidian* was observed in one rat. The animal's diaphragm was streaked with narrow, white bodies, some of which came out in water. After making both longitudinal and cross sections of the bodies, they were identified as Miescher's tubes of *Sarcocystis muris*. The highest incidence of this parasite noted in the literature was in a report by Tsuchiya and Rector (1935) in which they stated that 11 out of 100 rats examined in St. Louis had *S. muris*.

Rats from a single location.—Table 3 shows the results of a special study which was made of a series of rats from a single location over a year's time. In addition to the figures given in the table, the following information is presented. The most abundant parasite was the tropical rat mite, of which a total of 1917 were collected, the largest number from a single rat being more than 250. The louse was far behind the mite in numbers, a total of 146 being collected; the largest number from a single rat was 30. A total of 72 tapeworms were removed, the largest number from a single rat being 14.

Although the total number of 43 rats caught at this location is not large enough to permit truly significant conclusions to be drawn, several interesting observations were made. By consulting Table 3 it can be seen that lice decreased in numbers during the spring; not a single louse was found on the 13 rats examined during the hot months of August and September, but in October they began to appear again. From November through January, each rat caught was found to harbor lice, just as had been the case in the preceding February and April. The mites present a different story. They were present in large numbers in the spring, but, although mites were present on every rat caught from April through the following January, the mites showed a striking and steady decline in numbers from a peak of 90 per rat in May to 4 in January.

The tapeworms presented the most interesting problem. The first rats examined showed a heavy incidence of the worms, but the intermediate host escaped detection until the writer visited the location at night with a flashlight, at which time many black grain beetles, *Tenebrio obscurus*, were found to be abroad. The second beetle examined yielded a cysticercoid. Table 3 shows that there was a high incidence with heavy infestation of the tapeworm in the spring. However, the numbers decreased thereafter, and not a single tapeworm was recovered from 10 rats examined in October. This decline in cestode infestation may be correlated with the fact that the writer was unable to find any grain beetles in the fall.

Table 3 reveals that the oxyurid, *Syphacia obvelata*, did not appear until August, but that from August through December, 23 out of 24 rats examined were heavily infested. As the life cycle of this nematode is direct (Lawler, 1939), it is easy to understand how the infestation could spread quickly, but it is more difficult to explain how the first infestation was contracted. Presumably, a migratory rat introduced the worm.

* Spindler and Zimmerman (Jour. Parasitol. 31, Suppl., 1945, p. 13) presents evidence that *Sarcocystis* is a fungus rather than a protozoan.

Luttermoser (1936) reported that the incidence of helminths in adult rats in Baltimore was uniformly much higher than in the juveniles. That situation did not obtain in the present survey. A large number of the rats reported in Table 3 were young animals. It was evident that they acquired their infestations early in life.

SIGMODON HISPIDUS HISPIDUS

A total of 30 cotton rats were examined for helminths and ectoparasites during the period from September, 1948, through February, 1949. The rats were trapped from 4 locations: a grassy field, a grassy creek bank, and two vacant lots in residential areas. Twelve of the rats were males and thirteen were females; the sexes of five were not recorded. Davis gives the length of the cotton rat as 27 cm.; the average overall length in this survey was 21 cm., as several young rats were examined.

Table 4 indicates that the mite, *Atricholaelaps glasgowi* (Ewing 1925), and the louse, *Hoplopleura hirsuta* Ferris 1916, were almost equal in abundance. However, mites were usually much more numerous than lice; a single host harbored 67 lice, leaving only 45 lice to be distributed among the other 10 infested hosts in the table. Strandmann (1946) described a new species, *Atricholaelaps sigmodoni*, from the cotton rat, but correspondence with him revealed that he was writing a paper in which he would propose that *sigmodoni* be made a synonym of *glasgowi*. It is interesting to note that Harkema and Kartman (1948) reported that their cotton rats from North Carolina harbored *A. glasgowi*, while the rats from Georgia harbored *A. sigmodoni*.

TABLE 2.—Parasites of 102 roof rats, *Rattus r. frugivorus*

Taxonomic Group	Species of parasites	No. of hosts infested	Aver. no. of parasites per infested host	Total no. parasites collected	Largest no. of parasites from a single host
Cestoda	<i>Hymenolepis diminuta</i>	29	4.4	120	14
	<i>Oochoristica ratti</i>	1	1	1	1
	<i>Cysticercus fasciolaris</i>	1	1	1	1
Nematoda	<i>Syphacia obvelata</i>	45	Many	—	—
	<i>Mastophorus muris</i> var. <i>muris</i>	4	2.3	9	5
Anoplura	<i>Polyplax spinulosa</i>	49	15.6	734	111
Acarina	<i>Liponyssus bacoti</i>	61	47.9	2577	250±
	<i>Atricholaelaps mesoventralis</i>	1	3	3	3
Siphonaptera	<i>Leptopsylla segnis</i>	4	11.5	46	20
	<i>Echidnophaga gallinacea</i>	3	11.7	35	33
	<i>Xenopsylla cheopis</i>	1	5	5	5

Four rats harbored larvae of the lone star tick, *Amblyomma americanum*. These rats were caught on a grassy creek bank near a pasture where livestock was kept. The tick larvae were found only in November, although rats were caught at the same location both before and after that month. Randolph and Eads (1946) and Harkema and Kartman (1948) reported tick larvae on cotton rats; apparently, these rodents are good hosts for the larval and nymphal stages of ticks which will be found on larger animals as adults, and therein lies a possible danger of spreading certain rickettsial diseases.

The most abundant helminth harbored by the cotton rats in this survey was the trichostrongylid, *Longistriata adunca* Chandler 1932; some rats harbored this worm by the hundreds in the ileum. The only other nematode found in the present survey was the protospirurid, *Mastophorus muris* (Gmelin 1790) Chitwood 1938; its incidence was low. Harkema reported a high incidence in North Carolina and Georgia.

Three species of cestodes were found in the cotton rats. Table 4 shows that one-third of the rats harbored *Cysticercus fasciolaris* Rudolphi 1808, the larval form of the cat tapeworm, *Taenia taeniaeformis*. The largest number of cysts from the liver of a single host was 8, but all of these were small and possibly degenerate. As a rule, only one or two cysts were present. Harkema reported that the same was true of 31 positive cotton rats he examined. Luttermoser (1936) reported that an average of 1.35 cysts were present in the 165 Norway rats he found infested. He pointed out that this was a natural confirmation of Miller's demonstration of an acquired immunity for *C. fasciolaris* infestation in laboratory rats. Harkema made a similar statement in his survey of 1936. The present survey bears out these statements further. One cyst was found to contain a degenerate cysticercus which might have been the object of an immunological reaction; the hooks were large and well formed, but they were attached to a mere stub of a cysticercus. Baylis (1945) found cysts in cotton rats sent him but thought that possibly the infestation had been acquired while the rats were in captivity; Harkema's survey and the present survey show that the infestation is acquired in the wild state.

Another cestode found was the davaineid, *Raillietina bakeri*, which was described by Chandler from the tree squirrel in 1942. In several instances, the lower ileum and caecum contained detached, vase-shaped, gravid proglottids which were quite motile. One baffling observation was made in regard to this worm. A cotton rat was kept in a cage over a week-end, after which a long strobilus of about 55 proglottids was found in its bowl of drinking water. It is difficult to understand how a strobilus this long could have reached the outside intact.

The third species of cestode found in the cotton rats was an anoplocephalid, *Monoecocystus sigmodontis*. Chandler and Suttles (1922) described this worm under a different generic name which has become entrenched in the literature, but Reino S. Freeman has pointed out in correspondence that

TABLE 3.—Parasites of *Rattus r. frugivorus* from a single location

	Feb.	Apr.	May	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Total
No. Rats Caught	4	4	4	11	2	10	2	1	1	43
No. of Rats with <i>Polyplax spinulosa</i>	4	4	1	0	0	2	2	1	1	15
Aver. No. of lice per infested rat	12	5	1	0	0	2.5	30	11	1	9.7
No. of rats with <i>Liponyssus bacoti</i>	0	4	4	11	2	10	2	1	1	35
Aver. No. of mites per infested rat	0	82	90	84	47	17	15	10	4	54.8
No. of rats with <i>Hymenolepis diminuta</i>	1	3	3	3	2	0	1	1	0	14
Aver. No. of tapeworms per infested rat	11	11	4.7	3	4.5	0	2	5	0	5.1
No. of rats with <i>Syphacia obvelata</i>	0	0	0	9	2	10	2	1	0	24
Aver. No. of roundworms per infested rat	0	0	0	Many	Many	Many	Many	Many	0	Many

Fuhrmann (1932) gave the basis for reinstating the name *Monoecocestus*. An interesting feature of the worm was that cirri were frequently found to be protruded for a considerable length. One rat was examined which had a very recent, heavy infestation; about 75 young forms were attached to the wall of the jejunum. The lengths of these young forms varied from less than 1 mm. to about 3 mm.

It may be worthy of note that at three of the four locations where cotton rats were trapped, all three species of cestodes were found to be present. However, the two intestinal species, *R. bakeri* and *M. sigmodontis*, never occurred together in the same host.

DISCUSSION

COMPARISON OF PARASITE BURDENS OF

RATTUS R. FRUGIVORUS AND SIGMODON H. HISPIDUS

Reference to Tables 2 and 4 will reveal that several parasites were harbored by both the roof rat and the cotton rat, but closer examination of the tables will show that the few instances of overlapping of parasites are so limited in numbers as to be of little significance and that there was no overlapping of the principal parasites of the two rats. Some interesting observations can be made by comparing the principal helminths in relation to the difference in life histories of the hosts. Briefly, *R. rattus* is a climbing rat and is omnivorous, while *S. hispidus* is confined to the ground and is herbivorous (Ellerman, 1941, and Davis). Furthermore, *R. rattus* is an imported rat and has brought with it parasites which are known to be cosmopolitan in distribution among domestic rats, while *S. hispidus* is indigenous to the New World and would be expected to harbor native species of parasites. The trichostrongylid, *Longistriata adunca*, probably owes its success in the cotton rat to the fact that its host is a ground or burrowing rat. Hegner, Root, Augustine, and Huff (1938) state that all members of the subfamily Heligmosominae probably have a typical hookworm life cycle, which means that infective larvae hatch in the soil and enter the host by penetrating the skin. Thus, the habits of the cotton rat make it an ideal host for this worm. On the other hand, a close relative of *L. adunca*, *Nippostrongylus muris*, although commonly found in Norway rats in many regions, was not present in the domestic rats examined in this survey, probably because *R. rattus* is not in contact with the soil enough.

The above illustration shows how the climbing habit versus the burrowing habit may influence incidence of helminths. The following comparison will show how eating habits may influence helminth infestation. The roof rat, which is omnivorous, rather frequently harbored the tapeworm, *Hymenolepis diminuta*, which requires an insect intermediate host. The cotton rat, which is herbivorous, rather frequently harbored the anoplocephalid, *Monoecocestus sigmodontis*, which very likely utilizes an oribatid mite as its intermediate host. These minute mites live on grass, which is a staple food of cotton rats. Even before Stunkard (1941) worked out the life cycle of

some anoplocephalids with oribatid mites, Harkema (1936) stated that omnivorous rodents harbor cestodes requiring an insect as an intermediate host, while herbivorous rodents harbor species of *Anoplocephalidae*. Nevertheless, it must be pointed out that Harkema recently (1948) found *H. diminuta* in cotton rats of North Carolina.

It is interesting to note the following parallels in the incidence of ectoparasites and nematodes in the two rats, even though the parasites were of different species in the two hosts:

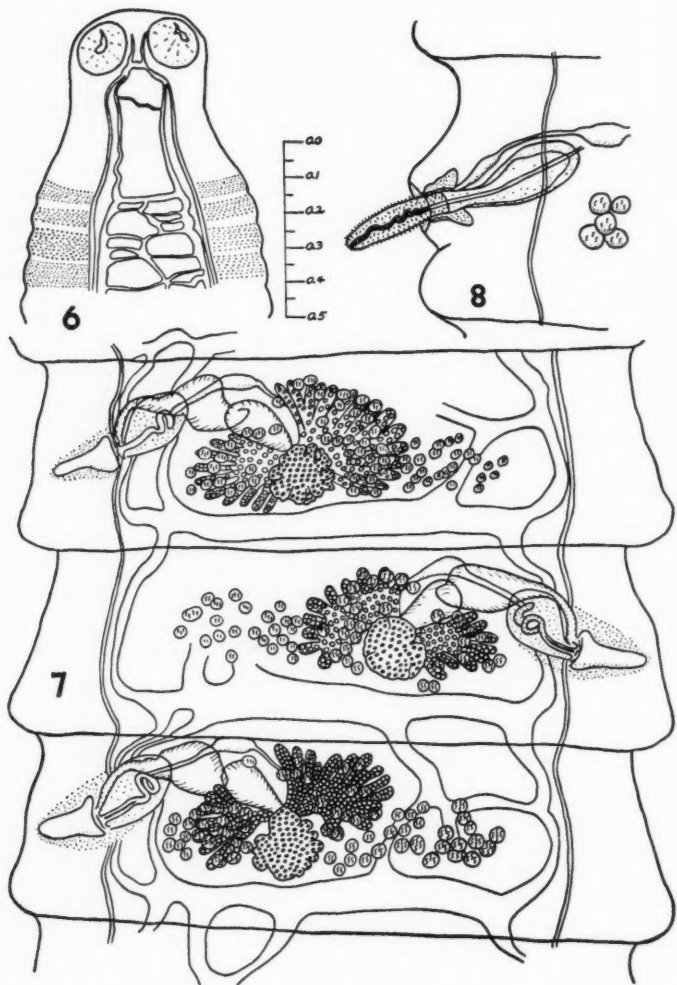
1. Both rats harbored more mites than lice, although mites enjoyed a much greater degree of dominance on the roof rat than on the cotton rat.
2. Both rats had a very low flea index.

TABLE 4.—The Parasites of 30 cotton rats, *Sigmodon h. hispidus*

Species of parasites Taxonomic Group		No. of hosts infested	Aver. no. of parasites per infested host	Total no. parasites collected	Largest no. of parasites from a single host
Cestoda	<i>Monoecocystus sigmodontis</i>	6	16.3	98	†75
	<i>Cysticercus fasciolaris</i>	10	2.6	26	† 8
	<i>Raillietina bakeri</i>	7	6.7	47	†20
Nematoda	<i>Longistriata adunca</i>	15	Many	—	—
	<i>Mastophorus muris</i> var. <i>muris</i>	5	2	10	6
	<i>M. muris</i> var. <i>ascaroides</i>	1	6	6	6
Anoplura	<i>Hoplopleura hirsuta</i>	12	17.6	212	100
Acarina	^b <i>Attricholaelaps glasgowi</i>	15	14.3	215	33
	<i>Amblyomma americanum</i> (larvae)	4	11.5	46	18
Siphonaptera	<i>Echidnophaga gallinacea</i>	1	2	2	2

* These figures for mites are not entirely accurate, as a small number of the nymphs and engorged specimens were found to be *Liponyssus bacoti*.

† Very young.



Figs. 6-8.—*Monoecocestus sigmodontis*. 6. Scolex. The extensive branching of the excretory system is shown; 7. Mature proglottids. The copulatory apparatus is not yet functional; 8. Everted cirrus. All drawings were made with the aid of a camera lucida.

3. In both rats, the most frequent and abundant helminth was a roundworm, and in both cases the worm was independent of an intermediate host in its life cycle. However, the two nematodes were widely separated taxonomically, being in different orders.

Before leaving the cotton rat, mention should be made of the filariid worm, *Litomosoides carinii*. Bertram (1946) and Williams (1948) are of the opinion that the mite, *Liponyssus bacoti*, is the only arthropod vector for this worm. The absence of the worm in the present survey may be correlated with the negligible incidence of *L. bacoti* on the cotton rats. Williams correlated the incidence of filariid worms with the incidence of *L. bacoti* from Florida cotton rats.

COMPARISON OF THE PARASITES OF *RATTUS R. FRUGIVORUS*
WITH THOSE REPORTED FROM *R. NORVEGICUS*

A large number of the parasitological surveys of rats have been carried out in regions where the Norway rat, *Rattus norvegicus*, was the dominant rat if not the only species reported. A study of the reports of these surveys reveals that certain helminths which occur very frequently in the Norway rat were not found in the rats from the present survey and appear to occur infrequently in *R. rattus* elsewhere, as well. These differences in helminth burdens may almost certainly be attributed to differences in the life histories of the two species of rats. Sinks (1949) summarizes the differences in habits. *R. norvegicus* is a burrowing rat which nests in its extensive underground burrows, whereas *R. rattus* is a climbing rat which nests above ground, usually in high places. The former rat likes meat, but the latter prefers fruits and vegetables; both eat much grain. Lentz (1910) states that the burrowing habit, combined with its greater strength and ferocity, has enabled the Norway rat to supplant other species in the temperate latitudes, but that in warmer climes it has not been able to drive out the others.

The following three nematodes are especially significant because of their frequency of occurrence in *R. norvegicus* and their virtual absence in *R. rattus*: *Capillaria hepatica*, *Trichosomoides crassicauda*, and *Nippostrongylus muris*. The latter two worms have a life cycle which is dependent upon the soil. None of the three were found in the present survey.

N. muris has been mentioned above in connection with its relative, *Longistriata adunca*, of the cotton rat. A striking example of the worm's dependence upon the soil was shown in Luttermeser's report (1936); the moist underground tunnels of Norway rats in a dump area of Baltimore proved to be ideal for the incubation of eggs and development of larvae of *N. muris*.

The nematode of the urinary bladder, *T. crassicauda*, appears to be even more widespread and abundant in Norway rats than is *N. muris*. Balfour (1922) reported it in 48% of 333 Norway rats examined in England; on the opposite side of the world, Chen (1933) reported it in Canton. Thomas

(1924) found a high incidence of the worm in Norway rats of Urbana, Illinois, and made a study of the life history. He stated that among the factors in distribution was the frequenting by the rats of moist places and dark underground burrows. Watanabe (1931) found none of the worms in 134 roof rats caught in Kobe, but 142 of 365 Norway rats caught there were infested.

The trichurid of the liver, *Capillaria hepatica*, appears to be one of the most frequent of all parasites in Norway rats. Luttermoser probably established a record when he found 2,140 of 2,500 Norway rats infested. Harkema (1936) and Belding (1942) are of the opinion that the infestation is acquired through the eating of dead infested rats. This may be the clue as to why *C. hepatica* is common in Norway rats but infrequent in roof rats. It was stated above that the Norway rat likes meat, and it is known that this rat will readily eat its dead fellows, but it is doubtful that the roof rat will do the same.

Although the rats in the present survey harbored none of the three common nematodes of Norway rats mentioned above, they showed a high incidence of the nematode, *Syphacia obvelata*, which appears to occur infrequently in Norway rats. Although Luttermoser found an extremely high incidence of several helminths in the 2,500 adult Norway rats examined, he found only 12 (0.48%) of those rats harboring *S. obvelata*. Other surveys also reveal a high incidence of other helminths in Norway rats with a low incidence of *S. obvelata*. In an ecological study of the helminths in 10 species of rodents in Washington, Rankin (1945) reported that *S. obvelata* was by far the most common parasite, both as to species of host and type of habitat. Very few other helminths were found. In the present survey of *Rattus r. frugivorus*, the only other helminth of numerical importance was the cestode, *Hymenolepis diminuta*, which was found in 29 of the 102 rats. The above findings have led the writer to form the following conjecture: Since the incidence of *S. obvelata* appears to be inversely proportional to the incidence of other helminths, and since the habitat of the worm is the caecum, posterior to the habitat of most of the other helminths of the gastro-intestinal tract, it may be possible that the excretory products of other helminths are toxic or inhibitory to *S. obvelata*. This conjecture seems the more plausible when it is recalled that *S. obvelata* is not dependent upon an intermediate host but has a direct cycle which should contribute to a rapid building up of the infestation if some inhibitory factor is not present.

An observation is presented concerning the low incidence of fleas found in this survey. Eskey (1938) examined 3,027 rats in a San Francisco survey and found that *R. norvegicus* outnumbered *R. rattus* 3 to 1 and had twice as many fleas. This would seem to indicate that the nests of *R. norvegicus* in moist underground burrows are more favorable for the development of flea larvae than the dry, above-ground nests of *R. rattus*.

SUMMARY

1. A total of 102 roof rats, *Rattus rattus frugivorus*, were examined for their parasites during the period from February, 1948, to March, 1949.

The rats were caught at 16 different locations within a 20-mile radius of College Station, Texas.

2. The rats harbored 5 different species of helminths, which were as follows: *Hymenolepis diminuta*, *Cysticercus fasciolaris*, *Oochoristica ratti*, *Syphacia obvelata*, and *Mastophorus muris* var. *muris*.

3. The roof rats harbored 5 species of ectoparasites, which were as follows: *Liponyssus bacoti*, *Atricholaelaps megaventralis*, *Polypylax spinulosa*, *Leptopsylla segnis*, *Xenopsylla cheopis*, and *Echidnophaga gallinacea*.

4. A total of 30 cotton rats, *Sigmodon hispidus hispidus*, were examined for their parasites during the period from September, 1948, to February, 1949. The rats were caught from 4 locations in the immediate vicinity of College Station, Texas.

5. The cotton rats harbored 5 species of helminths, which were as follows: *Monoecocestus sigmodontis*, *Railletina bakeri*, *Cysticercus fasciolaris*, *Longistriata adunca*, *Mastophorus muris* var. *muris*, and *M. muris* var. *ascaroides*.

6. The cotton rats harbored 5 species of ectoparasites, which were as follows: *Hoplopleura hirsuta*, *Atricholaelaps glasgowi*, *Liponyssus bacoti* (nymphs), *Amblyomma americanum* (larvae), and *Echidnophaga gallinacea*.

7. There was no significant overlapping of parasites in the roof rat and the cotton rat.

8. Differences in the incidence of parasites in different species of rats are correlated with differences in the habits of the hosts.

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Origin of Tetrapod Limbs

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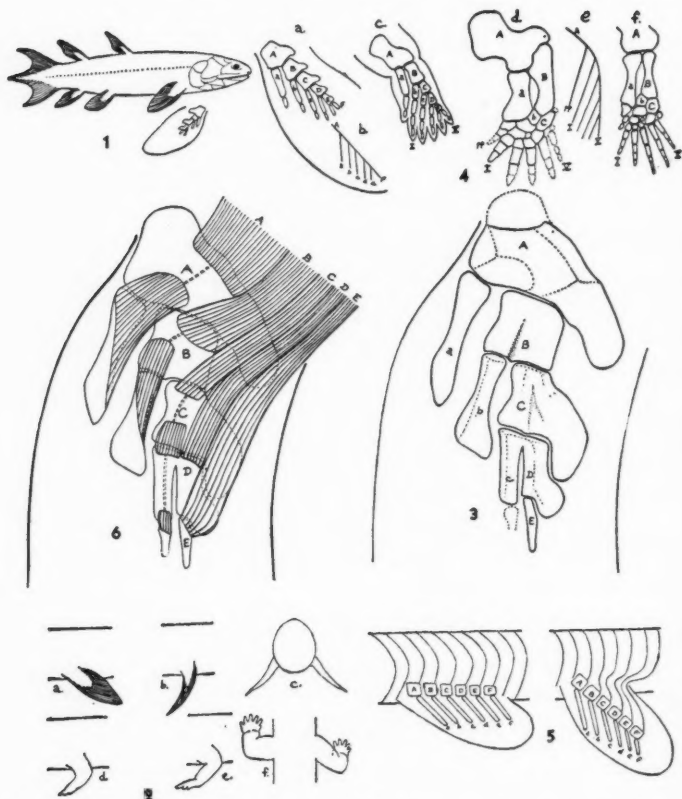
It is now widely understood that the more primitive Devonian lobe-fins, suborder Rhipidistia of the order Crossopterygii, were the fishes among which the ancestors of Amphibia must be sought. No single known genus, however, will necessarily show the precise structural antecedents of the Amphibia. The Rhipidistia of which the paired fin structure is adequately known are *Eusthenopteron*, *Sauripterus* and *Tristichopterus*. They were fishes in form and, no doubt, in behavior. They had not begun to crawl on land. The form and functions of their fins must therefore be accounted for solely by their use as swimming appendages, not by anticipation of the tetrapod limb.

Recent contributors to the study of the origin of tetrapod limbs include Romer and Byrne (1931), Howell (1935), Holmgren (1939), Gregory and Raven (1941), Westoll (1943a, b), and Romer (1949). Several views are represented among these, but the fullest interpretation seems to be that of Westoll, based in part on Gregory and Raven. There would be little justification for adding to the ideas already expressed, were it not that the results presented here seem a bit simpler than most, and that the writer cannot help questioning a restoration of the pre-amphibian pectoral limb in Romer's admirable text (1949).

STRUCTURE AND FUNCTION OF THE RHIPIDISTIAN FIN

Rhipidistia were predatory freshwater fishes living from the Lower Devonian (*Porolepis*) to the Permian (*Ectosteorhachis* and *Megalichthys*). The form of both the median and the paired fins (*Eusthenopteron*, fig. 1) suggests that these fishes were slow in action, except for occasional tail-propelled dashes to escape attack or capture prey. In rapid swimming the paired fins were evidently held in a trailing position close to the body, with the anterior borders down, a position corresponding closely to that of the legs of an aquatic salamander. But when idling, the fish probably abducted its paired fins to a position like that shown in figs. 1 and 2c. The striking similarity in shape and skeletal structure of the pectorals, pelvics, dorsals and anal implies rather similar functions for all of these.

Abduction and elevation (the same motion) of the pectorals were performed by a group of antero-dorsal muscles, equivalent to the levators in most fishes, originating on the body and inserting on the fin-skeleton. Abduction and depression (again essentially the same motion) were caused by a similar postero-ventral group, equivalent to the depressors of most fishes. Romer (1924) pointed out the general features of these two antagonistic sets, derived from myotomes in fishes by a splitting of the muscle-buds in



Figs. 1-4.—1. *Eusthenopteron*, and pectoral fin skeleton; 2a. Lateral view of Rhipidistian pectoral fin in trailing position, anterior margin down; 2b. The same, with fin bent forward, as when the tip rests on the bottom; 2c. Optical cross-section of fish with fin-tips touching bottom; 2d. Lateral view of hypothetical intermediate limb, showing rudimentary digits, and angle at elbow; 2e. Lateral view of primitive Amphibian limb; 2f. The same from above, showing elbow and wrist action; 3. Pectoral fin skeleton of *Eusthenopteron foordi*, drawn from Buffalo Museum specimen E2644; 4a. Diagram of Crossopterygian pectoral fin skeleton; 4b. Schema of axial and radial pattern in a; 4c. Hypothetical intermediate limb skeleton (compare 2d); 4d. Fore limb of *Eryops* (redrawn from Gregory and Raven, 1941); 4e. Schema of axial and radial pattern in d and f; 4f. Hind limb of *Trematops* (redrawn from Gregory and Raven, 1941). 5. Diagram of relationships between axial elements (A-F), muscle segments, and radial elements (a-f), in developing Rhipidistian paired fins. 6. Diagrammatic reconstruction of fin muscles of *Eusthenopteron foordi*, based on the skeleton shown in fig. 3.

ABBREVIATIONS: I-V, digits; A-F, axial elements; a-e, radials; pp, prepollex.

the embryo, and showed that they are still recognizable as dorsal and ventral groups in tetrapods, although here they develop from limb-bud mesenchyme and not from myotomes.

That the anterior border of the pectoral fin was the lower has been disputed (Romer and Byrne, 1931, followed by Howell, 1935), but other authors are convinced that it was. To the present writer the evidence seems clear, from a study of *Eusthenopteron* in the Buffalo Museum of Science. Specimen E2644, from which fig. 3 is drawn, shows by its orientation to adjacent parts of the body that it is the external face of a left pectoral. The heavier dermal rays, indicating the anterior edge, lie along the more ventral margin as the fin rests against the body. This differs from the position of pectorals in lungfishes and Actinopteri, in which the anterior margin may be strictly anterior, or turned up. Incidentally, the specimen cited does not permit me to conclude that the posterior border reached any nearer to the basal articulation than is shown in the figure, which thus indicates a relatively broad attachment of the fin to the body.

The linear series of "axial" bones in the fin (fig. 3, A-E) reached nearly halfway to its tip. Their flattened surfaces and the manner of their articulation imply an undulatory movement within the fin, in addition to those described above. Some slight bending, to produce a concave or convex arching of the surface, may have been possible because the radials *a* and *b* are free. That this was slight indeed is suggested by the immovable fusion of the third radial, *c*, with the axial bone, *D*. The "postaxial" flanges on *A*, *C*, and *D* were undoubtedly connected with one another by a ligamentous sheet in the same plane, and both their outer and inner flat surfaces provided for the attachment of muscles from the body. (In this way they were analogous to the thin flat neural spines of many mammals, along both sides of which run muscle masses.) The pattern of the fin skeleton in *Eusthenopteron* is the simplest known in Rhipidistia, and therefore most nearly suggests the basic pattern for the group. It shows only two or three apparent specializations, notably the lack of a flange on *B*, and the partial fusion of *c* and *D*. We may then venture to construct a diagrammatic crossopterygian fin-skeleton as in fig. 4a. It must be emphasized that the postaxial flanges are thin blades lying in a plane parallel to the fin-surfaces; therefore only their faces, and not the distal or proximal edges, could serve for effective muscle attachment. Axial *A*, of course, articulated with the small scapulo-coracoid bone of the pectoral girdle.

The most illuminating idea presented by Westoll (1943b) is that the axial series of bones corresponds to a series of basals in the fins of most fishes, and that, like the basals, they have a developmental relationship to the muscle segments. Fig. 5 is a diagram of this scheme. Westoll infers that the myomeres of the body were related, in order, to the muscles that moved the axials of the fin. A table of the innervation of shoulder and limb muscles by the cervical (3 to 8) and first thoracic nerves in man supports Westoll's contention by showing that the proximal musculature receives the more anterior innervation, and the distal muscles receive the more posterior

nerves. Presumably this is true throughout the tetrapods, but a full analysis is not available. It would seem to follow, if this view is correct, that each radial ("preaxial") piece was moved by a pair of muscles derived from those which moved the corresponding axial piece and having the same innervation.

Figure 6 combines the ideas so far stated in a tentative restoration of the levator or abductor group of muscles in the pectoral paddle of *Eusthenopteron*. The double broken lines between muscles indicate a common innervation, although not necessarily the course of the nerves. The abductor or depressor group would be shown as approximately a mirror image of these, on the lower side of the fin. No doubt the mass of fin-muscle on the side of the body spread widely on the surface of the body myomeres and formed a broad, fan-shaped muscle comparable to the latissimus-deltoides group in tetrapods (cf. Romer, 1949). Likewise the basal portion of those on the ventral side would spread on the body as a ventral group, comparable to the pectoralis-coracohumeralis group in tetrapods. Undulation of the fin is accounted for by the spread of muscle-slips across successive joints of the axial series, as well as by the separate radial muscles. All details are highly uncertain, although some faint indications of ridges, shown by dotted lines on the bones of fig. 3, have been taken as partial guides in the reconstruction. Probably there was at least one muscle slip attached more anteriorly on the first axial bone than any that are shown. If so, it might have inserted on the triangular area shown on the anterior edge in fig. 3. Such a muscle, and its counterpart on the lower face, would permit the fin to be drawn forward in the plane of its surface, that is, extended from the body, in opposition to the combined pull of those located behind it.

The great difficulty is to know how far the muscles reaching to the posterior and distal parts of the fin may have been fused, reduced, or modified from the scheme here suggested. But, aside from a certain amount of narrowing or compression as they entered the fin from the body, it seems likely that they were at least as large as shown. In the change to the tetrapod limb two fundamental differences appear: loss of any indication of body segmentation in the muscles of the limb, and failure of the embryonic myotomes to contribute to limb-musculature. Presumably these changes took place when the amphibian type of limb first evolved, because it would be unworkable without the mechanical segregation of its intrinsic muscles from those of the body.

EVOLUTION OF THE WALKING LIMB

We have now to consider the probable changes of function, position and form of the paired limbs, by which they ceased to be fin-paddles and became legs and feet capable of bearing the weight of the body off the ground. The circumstances of this change need only be mentioned briefly: an increasing elevation of the land surface in Late Devonian time, consequently more arid climate than before, and the probability of seasonal rainfall and desert conditions in many areas. It has been suggested that some

lobefin living in a river subject to seasonal drought may have wriggled out of drying pools for short distances to get into deeper, more permanent water.

Undoubtedly the trailing pectoral and pelvic paddles served to prop or balance the resting fish on the shallow bottom, although without bearing its weight; this is true of many fishes today. But the rhipidistian paddles were unlike others in orientation, having a deflected anterior margin (fig. 2a). For the resting fish to move slowly forward, contraction of the abductor (depressor) muscles would impart a downward, backward thrust to the fin, causing the body to lift up and forward. That a slight sigmoid wriggling of the body accompanied this is a safe inference from the form of the whole fish. The part of each fin that had rested lightly against the bottom would, by its inertia and the friction of the bottom, as well as pressure of the water, bend momentarily forward when a backward thrust was given to the fin-base (fig. 2b). It requires but one assumption, that the right and left fins were used alternately, synchronizing with the bending of the body, to provide the elements of an amphibian type of locomotion *before the lobefin ever emerged from the water*. This does not mean, however, that the structural changes necessary for land walking could have taken place here.

The only way in which an adaptive premium could have been put on reduction of the fin-membrane and its dermal rays would be, presumably, that the "fish," to escape competitors or for other reasons, spent some essential part of its adult life out of water. Westoll (1943b) says that the earliest known amphibian footprints show no evidence of slipping or sliding when the body was pushed ahead. Evidently the mechanism for support and movement was well established and was adequate to give firm footing. This mechanism involved, first, a foot whose digits pointed forward and stayed so while the wrist or ankle bent above them; second, an elbow or knee joint between axials A and B of the pectoral and pelvic limbs, respectively. The skeletal structure of such a limb is suggested in fig. 4c, and its outward appearance in fig. 2 d-f. In the latter, e and f are lateral and dorsal views of an amphibian fore limb.

On the basis that (1) the anterior margin of each paired fin of the Rhipidistia was tilted down, (2) the first use of the fin for propulsion in contact with a solid substratum must automatically have placed the ventro-medial surface down and pointed it forward, and (3) the reduction of fin membrane would result in bringing the existing radials (not axials) to the contact-edge, we may infer that (1) no twisting inversion of the limb (Romer, 1949) is necessary, and (2) the inward twist of the foot postulated by Gregory and Raven (1941) and by Westoll (1943) is also unnecessary, having been established already in the action of the fin and the pattern of its radials. That the number of radials in each diagonal series was increased somewhat over that known in any rhipidistian is not difficult to grant, but that the number of diagonal series was greater than 5

or 6 seems improbable, nor were these series dichotomous, as in *Sauripterus*. Thus the fundamental pattern of the primitive amphibian limb-skeleton, including the foot, involves no radical addition, reduction or shifting of parts from that of the crossopterygian.

Moreover, the diagonal relationship between radials and axials suggested in fig. 2c is seen even as far up the labyrinthodont scale as *Eryops* (fig. 2d) and *Trematops* (fig. 2f), in the pattern of carpals and tarsals. While it is not yet possible to prove a one-to-one correspondence of the primitive tetrapod foot and limb bones to those of the crossopterygian fin, the evidence seems to favor placing the most distal axial bones of the fish at the posterior edge of the tetrapod foot. This concept has the advantage of accounting directly for the muscle-innervation pattern mentioned above, and makes it unnecessary either to drop out certain central carpal bones or to add more mesenchyme to the posterior margin of the limb by migration from the body, as suggested by Westoll.

Thus there appears to be no need to seek a foot-axis and then attempt to bring the fin-axis around to the same position. The contribution of Holmgren (1939) to this problem is valuable for the embryological data which he supplies from studies of modern Amphibia, but there is no apparent reason to suppose that a true axis is represented among the middle rows of developing elements in the foot; rather they agree quite as well with the oblique radial pattern here postulated. The ulnare (fibulare of the pes) and possibly the 5th metapodial-phalangeal series represents the fin axis extended by reduplication of elements in line with one another. Holmgren, by the way, has shown that the "axis" of the fin of *Ceratodus* is not an actual metapterygial axis, but a serial multiplication of one line of radials; this perhaps explains why only 3 myotomes and segmental nerves supply the fin, and also gives an example of the freedom with which serial multiplication can take place.

The radius-radiale series apparently leads to a prepollex in early Amphibia, but the evidence for its existence is not absolutely convincing. The next radial series, from axial B, includes the intermedium and leads apparently to digit I. Succeeding radial series appear to lead to the next digits, in order. When a greater number of primitive amphibian foot-skeletons become available, it is likely that a virtually complete pattern, derivable from the fin, will be seen; that it will show no deletions; and that the metapodials and phalanges will stand in line with radial series already present, from which they have arisen by serial reduplication.

SUMMARY

The skeletal plan of the crossopterygian paired fins and of the primitive tetrapod limb is interpreted as an axial series of bones (mesomeres), each with one or more obliquely placed pre-axials (radials). No deletions appear to be necessary in accounting for the derivation of the tetrapod limb, nor is it thought necessary to add any postaxial elements. The transformation of pectoral and pelvic fins to limbs is essentially alike, except for the different

angles of knee and elbow; little torsion and no inversion occurred in either. Indeed it is suggested that the primary mechanical features of amphibian locomotion were already present in the completely aquatic fish. Limb muscles are restored in the pectoral fin of *Eusthenopteron*; the postaxial flanges are considered as areas of insertion of muscles arising from myomeres of the body.

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Notes and Discussion

Emendation of Zoological Names

A careful study of the proceedings of the Paris (1948) meeting of the International Commission on Zoological Nomenclature shows some trends which are disturbing, and to some extent confusing. In particular is this true in a number of decisions taken with regard to emendation of names, decisions which were primarily dispositions of particular cases, but which were also framed to have wide application. In view of this confusion, it seems wise to seek basic principles which may serve as guides, and to restate them.

A system of nomenclature in zoology exists to permit unambiguous reference to any given animal. This goal can be achieved if there is agreement among all workers that (a) a name may have only one meaning, and (b) a given animal may have only one name. Rules of nomenclature exist to provide an agreed means of determining (a) which meaning shall prevail when a name has been used in two or more senses, and (b) which name shall apply when more than one has been used for the same animal.

In the Linnean system of nomenclature each genus of animals is uniquely denoted by one word, each species by two words (one the generic name, the other the trivial). These words need not have in themselves any meaning, but usually in proposing a new name an author will select a word which by description, or association, or otherwise, has connotations which act as *aides mémoires*. It is important to see this point clearly. It is the uniqueness of the combination of letters that is important, and that alone makes the name an acceptable one in nomenclature. The "meaning," if any, is entirely secondary. So secondary that even though the "meaning" be completely incongruous (e.g. if a minute species is named *gigas*, or if a black species is named *rubrus*) the name still stands as a valid one.

A problem arises when, in the opinion of some worker, a describing author has planned that his name should have a certain meaning but has not, in fact, framed the name in such a way that this meaning is inherent. From this situation arises the suggestion that some names should be emended, to give them a form more consonant with the intention of their author. Let us examine this suggestion in some detail.

First of all, since emendation of a name means that a given animal has two names rather than one, I think it will be agreed that as a matter of principle every emendation is bad. If emendation is to be tolerated at all, it must be because the alternative condition is demonstrably worse. (Some would hold that the form still has only one name, the emended one, but this is clearly a fiction. Nothing can expunge the original name from the literature: no agency can collect all copies of the original work and alter them. No certainty can exist that all later workers referring to the original work will also have at hand the emending paper. In short, the original name exists, and it cannot be legislated into non-existence.) Let us consider some of the situations which, in the opinion of the Commission at Paris, are so intolerable that emendations must be made.

I

Should a name based on a personal name be emended because this latter name has been misspelt? Let us first of all be clear, that we are not discussing the case where I state that a species is dedicated to Dr. J. Marvin Weller, but the name inadvertently gets printed *X. walleri*; such *lapsi calami* have always been emendable, since it is obvious from the original paper itself that an error has been made, and what it should be. No, the case here is one in which, with the same intent, I state that a new species *X. walleri* is dedicated to Dr. J. Marvin Waller, of the University of Chicago. The Commission has held that such names are emendable, presumably on the grounds that "everybody" knows Dr. Weller, or can look him up in American Men of Science.

But authors do not confine their name-giving to colleagues who are in such reference works. Species are dedicated to wives, obscure benefactors, chance donors of specimens, and the like. If I describe a new species as *X. graveli*, and dedicate it to M. Gravel, the quarrymaster of Chateau Richer who has aided my studies by his cooperation, and it later

turns out that I have been misled by the sound of his name, which is spelled Gravelle, is this name to be changed to *X. gravellei*?

Wherein lies the difference? In both cases detection of the existence of an error is only possible to one in possession of special information, not included in the paper in which the name is proposed. Where can we draw the line between names which "everybody" knows, and those which are obviously local? Certainly my knowledge of Slavic patronymics is so slight that I would never detect an error which might be "obvious" to another worker. Must I check the spelling of all dedicatory names proposed by Russian colleagues?

Again, the Commission held that a name was to be emended if it were based on a Greek word, and that Greek word itself had been misspelled by the original author. Specifically, it was ruled that the generic name *Psodon*, which was said by its original author to be derived from the Greek word $\Psi\omicron\Delta\omicron\Sigma$, should be changed to *Psolon*, since "obviously" the author had mistaken a *lambda* for a *delta* and should have written the Greek word as $\Psi\omicron\Lambda\omicron\Sigma$. Admittedly this error was made, but is it "obvious"? Certainly not to me.

Suppose that I erect a new genus *Swooshla*, stating that the name is derived from the Siwash word for "bog," my animal being a swamp-dweller. Is the name to be emended if a more learned colleague points out that my informant must have been toothless, since the word is properly *Spooshla*, a fact well known to all students of Siwash?

But, it will be protested, zoologists are not expected to know Siwash, whereas every educated man knows Greek. Is not this a pretense, and completely unrealistic? Most zoologists, I suspect, have, like myself, painfully acquired the ability to thumb through Lidell and Scott and to make a stab at the gender of roots found therein. A very few, and those of an older generation, have had a year of Homer in their youth. That our ranks contain any real Greek scholars I seriously doubt. Certainly the ability to see as "obvious" someone else's error in a Greek word is beyond me, and I think it is beyond most of my colleagues.

Interestingly enough, the Rules seem to make no specific provision for misspelling of Latin words and consequent names based on them. Possibly the thought is that no zoologist would make such an appalling blunder. If so, banish the thought. We have paleontologists who unblushingly make trivial names like *squawcreekensis*, *powwowensis* and *rockcrossingensis*. Are these men to be trusted to spell a Latin root correctly?

III

The Commission does not seem quite decided what should be done about errors in geographic assignment of animals. It has been held that if, due to an error in labelling, I state that an animal is found in Lake Erin, and name it *X. erinensis*, and it later turns out that the animal really came from Lake Erie, then this name is to be emended to *X. ericensis*, or perhaps *X. eriensis*. But if I state that an animal comes from California and call it *Y. californicus*, then that name is not emendable if the label was wrong, and the habitat is truly the Philippine Islands. (An apparent exception is that Irish animals named *britannicus* by politically naive foreigners are to be renamed.)

Geographical names can be very tricky. North America is littered with place names derived from Indian roots, and now differing in spelling. If an author states that he has a specimen from Onawa, Iowa, and names it *Z. onawana*, then I am not going to question it because I know there is an Onaway in Michigan. I just presume that this is a town I haven't heard of, and accept his word for the spelling. Just as I accept a name said to be based on that of an African lake or a Chinese hill without question.

Here again, detection of an error is only possible to one possessed of special knowledge, and not to workers generally.

IV

These cases all involve examples where the naming author has stated the derivation of his name. I do not think any other cases need be considered. If I propose a name without indicating a meaning for it, then no intention of meaning can ever be proven from the original publication. I have just been considering an enlightening example.

In 1858 Salter and Billings (Geol. Survey Canada, Decade 3, p. 86 seq.) described a new genus of echinoderms, *Cyclocystoides*, and in it the new species *C. davisii*. The Paris meeting ruled that all trivial names based on patronymics in the genitive must be formed by the simple addition of -i, -ae, -orum or -arum to the family name. It might be said that this trivial name is "obviously" based on a family name Davis, but was it intended to honor Mr. Davis, Miss Davis, the whole family? Reference to the original paper shows that the only person mentioned whose name approaches Davis, is the collector of the specimen, J. E. Davies, Esq., F.G.S. "Obviously," then, the name should have been *C. davisii*, or should it? The only other species described by Salter and Billings at the same time was *C. halli*, and it was specifically dedicated to Professor J. Hall, although the specimens had been collected by Sir W. E. Logan and J. Richardson.

I think the only obvious conclusion is that Salter and Billings proposed a name made up of the seven letters *davisii*. Any thoughts about why they chose these letters are to be classified as speculations, and certainly afford no grounds for altering the name.

V

What conclusion may we draw from all this discussion? I think only one. That an error which can only be detected by one having special knowledge of Greek, of biography, of Siwash, should not be emendable, since those with the special knowledge would emend it, while those lacking this information would use the original name, and we would have a dual nomenclature. That the only allowable emendations are those errors so obviously apparent in the original paper (for we cannot presume that a worker would see later papers) that every worker would recognize the need for emendation, and that every worker would emend it in the same way.

I think it is obvious that permissive emendation is unthinkable. If any change is to be made, it must be made by everyone, so that the original name passes completely out of current usage. To have some using an original name, some an emended one, would be chaotic. It follows that the necessity for emendation must be obvious to all who might use the name, and the correct form must also be so obvious that none can miss it.

The Commission still has the power to validate names in case of hardship, but this should be done by suspending the Rules, and not by tinkering with them.

The Commission has announced that it plans to study the question of emendation further, and to consider it again at the Copenhagen meetings of 1953. Until then, zoologists may present their opinions to the Commission. It is not too much to hope that the Commission may be convinced of the confusion which follows piece-meal accretion of exceptions, and may be moved to a firm declaration that only obvious *lapsi* may be emended.

VI

Let me not be mistaken here. By all means let us try to instill in our students, and shame into our colleagues, some sense of the aesthetic in zoological names. Let us hold up standards of brevity, euphony, and classical appropriateness as desirable. Let us lay down for the unlettered suggestions as to how names may be formed. But if through ignorance, or inadvertence, or perversity, an author publishes an uncouth name, then let it stand as a monument to his barbarity. He will not be offended, since he is oblivious to his fault, and his name will serve as a dreadful warning to the young, and a source of self-complacency to the smug.—G. WINSTON SINCLAIR, Geology Department, University of Michigan, Ann Arbor.

A Technique for Anesthetizing Fresh Water Ostracodes

This study was started in conjunction with the observation of the relationship between fresh water ostracodes and their fossil ancestors. It was desired to find a method by which activity would be retarded and the shell left agape, so that the appendages could be readily studied in motion and at rest. The hypnotic used in the technique described here has the advantage over other hypnotic and killing agents tested as it produces a

complete loss of control of the adductor muscles and those of the appendages so as to cause a gaping of the shell and the extension of the appendages outside the carapace. While in this state, camera lucida drawings can be made of the appendages, after which the specimen can be revived to normal, or killed by overdosing.

To 50 cc. distilled water add 1 gm. Chloretone $(CH_3)_2C(OH)CCl_3$ and heat the mixture to $85^\circ C$. for 3 minutes, allow the solution to set for 24 hours, after which decant the liquid from any remaining crystals [the crystals may be reused]. The solution may be stored for an indefinite period of time in an amber bottle or in the dark.

There appears to be a slight variation in the concentration needed to anesthetize the various genera: *Cypridopsis vidua* was found to require the highest concentration and an optimum ratio appears to be 60% Chloretone stock and 40% water; in other genera (e.g., *Candona*, *Ilyocypris*, *Chlamydotheca*, etc.) a 40% Chloretone stock is more satisfactory for complete recovery after anesthetization. As a rule, the early stages require a slightly lower concentration, whereas forms with eggs require a slightly higher concentration.

It is not significant whether the specimen is put into the solution or the solution added to the specimen already in water; the latter method was used during most of the research. The first symptom noted is an inability to control the appendages in organized movement, after which the swimming setae of the antennules and the setae of the antennae dilate and with the 2nd thoracic leg and furca are extended beyond the shell. The animal is now partially under anesthesia and the shell is agape. A large fecal pellet is usually deposited as the specimen is affected by the hypnotic. Movement may continue for 10 minutes [depending on the concentration of the solution]. Complete anesthesia expresses itself as a total loss of movement. For further study, the specimen is transferred to a solution, $\frac{1}{2}$ the concentration of the anesthetizing solution. The specimen can remain in this solution for a maximum of 15 minutes. If anesthesia progresses too far, the antennules rise high above the dorsum and become flexible; after reaching this stage, recovery to normal is possible only in rare cases. To revive the specimen it is placed in water of its normal environment.

This technique was also used successfully in studying cladocerans and copepods. Revival to normal was accomplished, in most cases, after anesthetization.—STUART A. LEVINSON, Department of Geology, Washington University, St. Louis, Mo.

A Fairy Shrimp New to Louisiana

Apparently Creaser's record* of *Streptocephalus sealii* Ryder, represents the only published report of an anostracan branchiopod for the state of Louisiana. Through the cooperation of Mr. Henry B. Chase of New Orleans, collections of temporary pond material made during the past twelve years were made available to the writer. In addition to numerous collections of *S. sealii* from the vicinity of Alton, Pearl River, and Covington in St. Tammany Parish, a species not hitherto reported for the state was found, as follows:

Eubranchipus holmani (Ryder).—This species has previously been reported from several localities in eastern United States, Connecticut to Virginia; and from as far west as Ohio and Tennessee. A collection of this species was made by Mr. Chase from a water oak-mayhaw pond near Alton, St. Tammany Parish, on February 9, 1939. Other collections were made from temporary ponds in the same general region on January 22, 1942 and February 11, 1943.

The writer has recently (February 21, 1951) taken this species, along with *S. sealii*, from a water oak pond near Alton; and has collected additional specimens from a gum pond near Florenville, St. Tammany Parish.

The writer wishes to express his thanks to Mr. Henry B. Chase for providing him with the collections referred to above; and to Dr. Ralph W. Dexter, Kent State University, who assisted in their identification.—WALTER G. MOORE, Department of Biology, Loyola University, New Orleans.

* Creaser, E. P. (1930). The North American Phyllopods of the Genus *Streptocephalus*. Occ. Pap. Mus. Zool., Univ. Michigan, No. 217, Pp. 1-10.

New Illinois Plant Records

The following plants constitute additions to the known flora of Illinois. All specimens were collected by the authors and are on deposit at Southern Illinois University and the University of Illinois.

Cimicifuga racemosa (L.) Nutt. var. *cordifolia* (Pursh) A. Gray.—Closed oak-hickory woods on talus, Jackson Hollow, Pope Co., August 17, 1950, No. 1135. Only a few of the observed plants had started to flower at this time.

Hypericum densiflorum var. *lobocarpum* (Gattinger) Svensen.—Bank of stream, east of Brookport, Massac Co., July 28, 1950, No. 1104.

Wolffiella floridana (J. D. Sm.) C. H. Thompson.—Wolf Lake swamp, Union Co., Nov. 4, 1950, No. 1163. The senior author has observed this plant in this area for several years.—WILLIAM M. BAILEY AND JULIUS R. SWAYNE, Southern Illinois University, Carbondale.

BOOK REVIEWS

SEA TURTLES AND THE TURTLE INDUSTRY OF THE WEST INDIES, FLORIDA, AND THE GULF OF MEXICO, WITH ANNOTATED BIBLIOGRAPHY. By R. M. Ingle and F. G. W. Smith. University of Miami Press, Fla. 1949. 107 pp., 2 figs. \$1.00.

Based primarily on a survey of the literature, this brochure attempts a summary of the status of the sea-turtle industry of western Atlantic waters. The aim in the study is toward better legislation for conservation and for maintenance of a profitable industry that is too often abused. In addition to summaries of statistics on the fisheries the authors also summarize the distribution, growth, habitat, food, breeding, migration, physiology, fishing methods, products, and cultivation of turtles. On page six is presented a summary of conclusions and recommendations, as follows:

"It is concluded that, while some areas are overfished, others are suffering from reduced breeding activity only and that the principal danger to the industry as a whole is interference with the nesting turtle.

"Growth rate and duration of breeding season has been insufficiently studied.

"Statistical information is lacking in many places and efforts should be made to remedy this deficiency.

"Turtle farming should be initiated locally by fishery officers, according to whether the local conditions are favorable or not.

"Egg taking and the capture of turtles on beaches should everywhere be rigidly enforced and penalties made sufficiently high to act as a real deterrent. Size limits are regarded as next in importance, and closed seasons, as an alternative to maximum catch restrictions are recommended wherever the average size has dropped to a dangerous extent.

"An educational program is recommended in order to enlist the aid of fishermen and others in law enforcement and the collection of information."

Although the publication contains much useful information there are a number of detracting points. Most noticeable is the inconsistency in taxonomy. On page 7 both the hawksbill and Kemp's turtles are given as being in the genus "*Thalassochelys*" (= *Thalassochelys*). On page 8 and 10, in the taxonomic listing, the hawksbill is placed in *Eretmochelys*. On page 9, Kemp's turtle is placed correctly in *Lepidochelys* and on page 10 in *Caretta*. The annotated bibliography contains 365 titles, but many of these have no bearing on the topic. Misspellings are numerous, the proof reading and editing were not well done.—R. L. LIVEZEY, University of Notre Dame, Notre Dame, Indiana.

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